IDOE

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INTERNATIONAL DECADE OF OCEAN EXPLORATION

PROGRESS REPORT VOLUME 5: APRIL 1975 to APRIL 1976

Reports in series:

International Decade of Ocean Exploration, Progress Report: January 1970 to July 1972, published January 1973

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October 1976

Nations in IDOE

Argentina
Australia
Belgium
Bolivia
Brazil
Canada
Chile
China, Republic of
Colombia
Denmark
Ecuador
Fiji
France
Germany, Dem. Rep. of
Germany, Fed. Rep. of
Greece
Guatemala
Iceland
India
Indonesia
Israel
Italy
Jamaica
Japan
Khmer Republic
Korea, Republic of
Malaysia
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New Zealand
Norway
Peru
Philippines
Portugal
Singapore
Spain
Sweden
Switzerland
Thailand
Tonga
Union of South Africa
United Kingdom
United States
USSR
Venezuela
Viet-Nam, Republic of

PREFACE

The International Decade of Ocean Exploration (IDOE) is a long-term, international, cooperative program to improve the use of the ocean and its resources for the benefit of mankind.

On March 8, 1968, the President of the United States proposed "an historic and unprecedented adventure—an International Decade of Ocean Exploration for the 1970's." In December 1968 the United Nations General Assembly endorsed "the concept of an international decade of ocean exploration to be undertaken within the framework of a long-term programme of research and exploration. . . ."

In late 1969, the Vice President of the United States, in his capacity as Chairman of the National Council on Marine Resources and Engineering Development, assigned responsibilty for planning, managing, and funding the U.S. program to the National Science Foundation (NSF), and set forth the following goals:

Preserve the ocean environment by accelerating scientific observations of the natural state of the ocean and its interactions with the coastal margin—to provide a basis for (a) assessing and predicting man-induced and natural modifications of the character of the oceans, (b) identifying damaging or irreversible effects of waste disposal at sea, and (c) comprehending the interaction of various levels of marine life to permit steps to prevent depletion or extinction of valuable species as a result of man's activities;

Improve environmental forecasting to help reduce hazards to life and property and permit more efficient use of marine resources—by improving physical and mathematical models of the ocean and atmosphere to provide the basis for increased accuracy, timeliness, and geographic precision of environmental forecasts;

Expand seabed assessment activities to permit better management—domestically and internationally—of marine mineral exploration and exploitation by acquiring needed knowledge of seabed topography, structure, physical and dynamic properties, and resource potential, and to assist industry in planning more detailed investigations;

Develop an ocean monitoring system to facilitate prediction of oceanographic and atmospheric conditions—through design and development of oceanographic data buoys and other remote sensing platforms:

Improve worldwide data exchange through modernizing and standardizing national and international marine data collection, processing, and distribution; and

Accelerate Decade planning to increase opportunities for international sharing of responsibilties and costs for ocean exploration, and to assure better use of limited exploration capabilities.

Shortly after receiving the Vice-President's charge, the National Science Foundation set up the Office for the International Decade of Ocean Exploration and began to define the United States program. In the first year of IDOE's

existence, three areas were chosen for priority attention: (1) environmental quality; (2) environmental forecasting; and (3) seabed assessment. In 1971, living resources was added as a fourth program area.

A key goal of IDOE has been to make sure that data from all projects will be available to future users. In pursuit of this objective, the IDOE Office of NSF contracted with the Environmental Data Service (EDS) of the National Oceanic and Atmospheric Administration to manage the scientific data for IDOE. The agreement included publishing this series of reports. EDS managers work with IDOE-supported scientists to compile and organize data from IDOE projects. Whenever possible programmers convert the original data into computer readable form. The data are stored in a way that allows fast retrieval and long-term preservation and are made available on either an exchange basis or for the cost of reproduction.

To alert scientists and others interested in what is going on in IDOE, EDS prepares the annual *IDOE Progress Report*. This is Volume 5 in that series. I hope it will be useful to those concerned about our advances in understanding the oceans and their importance for man's activities. Comments about the reports and IDOE programs are welcomed.

Feenan D. Jennings, Head
Office for the International
Decade of Ocean Exploration

INTRODUCTION

This report, the fifth in a series, provides the scientific community and other interested persons with information, data inventories, and lists of scientific reports derived from U.S. IDOE projects. The text is arranged according to established program areas for IDOE. Details of subprograms are given under appropriate programs. Currently funded projects are listed. Bibliographies follow subprogram text.

Appendix A contains the Report of Observations/Samples Collected by Oceanographic Programs (ROSCOP), a summary inventory of reported observations received during the period covered by this Report. All IDOE grant holders must submit ROSCOP reporting forms to NOAA Environmental Data Service's National Oceanographic Data Center (NODC) upon completion of a data collection activity. The ROSCOP summaries Appendix A follow the same program sequence as the text.

Two charts follow the Appendix. The first shows ocean areas for which data, ROSCOP summaries, and track charts have been received by NOAA's Environmental Data Service (EDS) during the period covered by this report. The second shows ocean areas for which data have been received by EDS from January 1970 to April 1976. Each area is about 1,100 by 1,100 km (600 by 600 nmi) and, although entirely shaded, may contain only one reported observation.

EDS either has the data, track charts, or papers described in this report in one of its center archives or knows where they may be obtained. Queries may be addressed to any of the following EDS centers:

National Oceanographic Data Center (NODC)
National Oceanic and Atmospheric Administration
Washington, DC 20235
Tel: (202) 634-7234
IDOE Project Leader: A. R. Picciolo

Marine Geology and Geophysics Branch
National Geophysical and Solar-Terrestrial Data Center (NGSDC)
National Oceanic and Atmospheric Administration
Boulder, CO 80302
Tel: (303) 499-1000 Ext. 6339
IDOE Project Leader: J. B. Grant

Environmental Science Information Center (ESIC)
National Oceanic and Atmospheric Administration
Washington, DC 20235
Tel: (202) 634-7334
IDOE Project Leader: W. Hardy

National Climatic Center (NCC)
National Oceanic and Atmospheric Administration
Federal Building
Asheville, NC 28801
Tel: (704) 258-2850 Ext. 765
IDOE Project Leader: R. Quayle

CONTENTS

Analysis of CEPEX samples takes place in mobile laboratories located ashore near the mooring site

Environmental Quality Program

This program is designed to provide information on the quality of the oceanic environment and the assessment and prediction of man's impact on this environment through research in geochemical processes and marine pollution. The present program consists of three major investigations: the Geochemical Ocean Sections Study GEOSECS, which is concerned with detailed measurement of physical and chemical characteristics of ocean waters along Arctic to Antarctic sections; the Pollutant Transfer Program, which involves investigations of mechanisms and pathways by which pollutants are transported to and within the oceans; and the Biological Effects Program, which assesses the impact of selected pollutants on marine organisms and communities.

Geochemical Ocean Sections (GEOSECS) Study

GEOSECS is an international cooperative program involving geochemists from 14 United States universities. Investigators from Belgium, Canada, France, Germany, India, Japan, and the United Kingdom are participating in the GEOSECS program or are carrying out similar programs coordinated by the United States. The U.S. program involved the occupation of 121 oceaographic stations in the Atlantic and 147 stations in the Pacific. These stations were located along north-south survey tracks and generally coincided with the paths of bottom-water currents. Samples of water and suspended materials collected at these stations and selected depths are being analyzed for approximately 40 physical and chemical parameters, including temperature, salinity, pH, alkalinity, P_{CO_2}, dissolved and trace gases, nutrients, trace metals, dissolved and particulate organic and inorganic matter, natural radionuclides, manmade radionuclides, and stable isotopes.

The data are being used to determine the stirring and reaction processes in the deep sea, the interchange of material between deep and surface waters, and the exchange of water and gases with the atmosphere. The data provide a baseline for measuring amounts of pollutants, specifically nuclear and waste products, that are being introduced into the ocean. Projects in this program are listed in table 1.

GEOSECS Data

The GEOSECS operation group at the Scripps Institution of Oceanography (SIO) has established a central data processing facility. This facility is presently producing special data reports for GEOSECS investigators and preparing a final data report of shipboard analysis and several detailed chemical oceanographic atlases. Laboratories have completed some analyses and have forwarded these data to SIO (table 2). Analyses of the remaining Atlantic and Pacific samples are being completed. The following data are available from NOAA Environmental Data Service's National Oceanographic Data Center.

NODC Accession No.: 74–0144
Organization: Scripps Institution of Oceanography
GEOSECS Operations Group
Investigator: Various GEOSECS participants
Grant No.: Various grants

GEOSECS Atlantic, Final Hydrographic Data Report, RV KNORR cruise 30, 24 July 1972 to 30 March 1973, 121 stations: depth, temperature, salinity, oxygen, silicate, PO_4, and NO_3. This data is the final edited version and supersedes the previously submitted GEOSECS Atlantic data submission.

GEOSECS Bibliography

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Edmond, J. and E. A. Boyle. 1975: Copper in surface waters south of New Zealand from GEOSECS stations in the Circumpolar Current, *Nature* 253(5487):107–109.

Hager, S. W., E. L. Atals, L. I. Gordon, A. W. Mantyla, and P. K. Park. 1972: A comparison at sea of manual and AutoAnalyzer analysis of phosphate, nitrate, and silicate, *Limnol. Oceanogr.* 17(6):931–937.

Moore, W. S. 1976: Sampling ^{228}Ra in the deep ocean, *Deep-Sea Res.* 22:519–523.

Östlund, H. G. and H. G. Dorsey. 1976: Rapid electrolytic enrichment and hydrogen gas proportional counting of tritium, in *Proceedings of International Conference on Low Radioactivity Measurements and Applications,* 6–10 October 1975, High Tatras, Czechoslovakia.

Stuiver, M. and W. S. Broecker. 1975: The ageing and circulation of West Atlantic Deep Water, in *Proceedings of the WMO/IAMAP Symposium on Long-Term Climatic Fluctuations,* Norwich, 18–23 August 1975. *WMO Publication* No. 42, Geneva, Switzerland, pp. 301–310.

Stuiver, M. and S. W. Robinson. 1974: University of Washington GEOSECS North Atlantic carbon-14 results, *Earth Planet. Sci. Lett.* 23(1):87–90.

Table 1.—U.S. institutions, investigators, and projects in GEOSECS program

Organization	Investigator	Project title
Atomic Energy Commission and Woods Hole Oceanographic Institution	H. L. Volchok V. T. Bowen	Fallout Radionuclides in Ocean Water Columns (Sr^{90}, Cs^{137}, $Pu^{238, 239}$)
University of California, San Diego, Scripps Institution of Oceanography	A. E. Bainbridge H. Craig	Operations Group and SIO Shipboard and Laboratory Measurements
The City University of New York, Queens College	T. Takahashi	Carbonate Chemistry of Seawater
Columbia University, Lamont-Doherty Geological Observatory	W. S. Broecker P. Biscaye	Analyses of GEOSECS Atlantic and Pacific Samples, Ra^{226}, Ra^{228}, Suspended Particulates (Mineralogy and Chemistry)
University of Hawaii	P. Kroopnick	Isotopic Measurements (C^{13}/C^{12}, O^{18}/O^{16}, D/H) in Dissolved Inorganic Carbon, Dissolved Oxygen, Atmospheric Water Vapor, and Atmospheric CO_2
Louisiana State University	L. M. Chan J. S. Hanor	Barium Analysis in Ocean Waters
Massachusetts Institute of Technology	J. M. Edmond	High-Precision Barium Measurements
University of Miami, Rosenstiel School of Marine and Atmospheric Science	H. G. Ostlund	Radiocarbon and Tritium Measurements
University of South Carolina	W. S. Moore	Measurement of Ra^{228} in Seawater
University of Southern California	T. L. Ku	Radium Analysis
University of Washington	M. Stuiver	C^{14} Ocean Water Analysis
Woods Hole Oceanographic Institution	D. W. Spencer	Particulate matter in the Atlantic and Pacific Oceans
	P. G. Brewer D. W. Spencer	Administrative and Logistic Activities
Yale University	K. K. Turekian	Strontium Analysis

Table 2.—Laboratories conducting trace element and radioactive constituent analyses for GEOSECS

Battelle Laboratories—Northwest, Richland, Wash.
Centre National de la Recherche Scientifique de Faibles Radioactivity, Gif-sur-Yvette, France
University of Hawaii, Honolulu, Hawaii
Lamont-Doherty Geological Observatory, Palisades, N.Y.
Louisiana State University, Baton Rouge, La.
McMaster University, Hamilton, Ontario, Canada
Physical Research Laboratory, Ahmedabab, India
Scripps Institution of Oceanography, La Jolla, Calif.
University of Southern California, Los Angeles, Calif.
University of Washington, Seattle, Wash.
Woods Hole Oceanographic Institution, Woods Hole, Mass.
Yale University, New Haven, Conn.

Stuiver, M., S. W. Robinson, H. G. Östlund, and H. G. Dorsey. 1974: Carbon-14 calibration between the University of Washington and the University of Miami GEOSECS laboratories, *Earth Planet. Sci. Lett.* 23(1):65–68.

Takahashi, Taro. 1975: Carbonate chemistry of sea water and the calcite compensation depth in the oceans, in Dissolution of Deep-Sea Carbonates, *Cushman Foundation for Foraminiferal Res. Spec. Pub.* No. 13, pp. 11–26.

Pollutant Transfer Program

In the Pollutant Transfer Program, initiated in 1972, processes that transfer pollutants from land sources to the oceans and movement and concentration of these pollutants in the oceans are being investigated. Objectives are to: (1) identify important transfer pathways and mechanisms, (2)

evaluate major environmental factors that influence transfer processes, and (3) develop principles governing the transfer of pollutants. Of special interest are the concentration and dispersal of pollutants at the air-sea interface, movement of pollutants through estuaries to continental shelf waters, deposition of pollutants in sediments, and the chemical form and degradation of these pollutants in the marine environment.

The atmosphere is a major route of transfer for chlorinated and petroleum hydrocarbons and trace metals. Results of studies on atmospheric transfer of trace metals suggest that, except for sea salts, most airborne trace metals over the open ocean and Antarctica are from normal weathering of the earth's crust. However, the concentrations of several easily vaporized trace metals (antimony, cadmium, copper, lead, selenium, and zinc) are greater than those predicted to be of crustal origin.

Several investigators are studying the atmospheric transport of heavy chlorinated hydrocarbons to the oceans. For example, scientists studying PCB transport in the Southern California area have shown that most residues are deposited within a radius of 100 km of the source. Thus, transport of particulate chlorinated hydrocarbons is not a global phenomenon.

Studies also give indirect evidence for atmospheric transport of PCB and DDT compounds to a more remote marine environment, based on observed distribution in the biota. Both of these compounds are universally present in terrestrial and marine Arctic wildlife that live in areas where transport by other pathways is highly unlikely. Marine birds, principally fish-eating species such as cormorants and pelicans or surface feeders such as petrels and shearwaters, have been used to assess present contamination patterns in the Pacific. The greatest concentrations of DDT residues are in the Southern California Bight. Their source is the Los Angeles sewer system. Elsewhere, aerial dispersal and rainout appear to account for most residues.

The principal routes by which pollutants reach coastal areas are rivers and sewage and industrial outfalls. Pollutants from these sources subject estuarine ecosystems to the most severe man-induced stresses in the marine environment.

An extensive investigation of the input of lead to the Southern California Bight from storm runoff and sewage outfalls has begun. This research indicates, in significant contrast to earlier investigations, that less than 1 percent of the waste effluent lead is dissolved while the rest is in particulate form. The isotopic composition of the dissolved lead also was considerably different from particulate lead, suggesting different sources for these two forms of lead. Extensive sampling of dissolved and particulate lead in the ocean in the vicinity of sewage outfalls, as well as in rain and storm runoff, is presently underway. Projects in this program are listed in table 3.

Table 3.—U.S. institutions, investigators, and projects in Pollutant Transfer Program

Organization	Investigator	Project title
California Institute of Technology	C. C. Patterson	Determination of Input and Transport of Pollutant Lead in Marine Environments Using Isotope Tracers
University of California, Bodega Marine Laboratory	R. Risebrough	Formulation of Mass Balance Equations for Polychlorinated Biphenyls in Marine Ecosytems
University of California, Scripps Institution of Oceanography	E. Goldberg	Fluxes of Synthetic Organics to the Marine Environment
University of Georgia, Skidaway Institute of Oceanography	H. L. Windom	The Uptake of Heavy Metals by Marine Phytoplankton
Harvard University, Bermuda Biological Station, Inc.	J. N. Butler B. F. Morris	Transfer of Petroleum Residues in Sargassum Communities and the Waters of the Sargasso Sea
University of Rhode Island	R. A. Duce	Atmospheric Pollutant Transfer and Deposition on Sea Surface
San Jose State University	J. H. Martin	Cadmium Transport to the Open Pacific Ocean via the California Current System
Texas A&M University	C. S. Giam	Phthalate and Chlorinated Hydrocarbon Transfer Processes in the Marine Environment
	B. J. Presley	Quantities and Forms of Pollutants Carried by the Mississippi River and Their Fate in the Gulf of Mexico
Woods Hole Oceanographic Institution	G. R. Harvey	A Survey of PCB and DDT compounds in the South Atlantic, and an Intercalibration of Methods for Determining These Compounds

Biological Effects Program

The purpose of this program is to investigate the effects of pollutants on marine organisms and ecological communities. Both laboratory and field experiments are included. Laboratory work is concerned mainly with effects of pollutants on single classes of organisms. Field studies are integrated into the Controlled Ecosystem Pollution Experiment (CEPEX). This cooperative research project of international scope involves trapping water and natural communities in large plastic enclosures (10 m diameter by 30 m deep) and assessing the effects of added pollutants on marine ecosystems—the long-term effects influencing the stability of marine populations. The initial CEPEX enclosures are located in Saanich Inlet, Vancouver Island, British Columbia. Projects relating to the Biological Effects Program and CEPEX are listed in tables 4 and 5, respectively.

In 1973, laboratory studies were started to evaluate the sublethal, low-level effects of trace metals, petroleum, and chlorinated hydrocarbons on the behavior and biochemical processes of individual classes of organisms. Bacteria, phytoplankton, zooplankton, and higher marine organisms were maintained in laboratories for this purpose.

Several pollutants were acutely toxic to these organisms in the parts-per-million (ppm) range. Generally, heavy metals, such as mercury, and chlorinated hydrocarbons (such as PCB-Aroclor 1254) were found to be more toxic than petroleum hydrocarbons to most species tested. Larvae were more sensitive to pollutants than adults of the same species. Crude oils from Kuwait and Louisiana and number 2 fuel oil were found to be toxic to microalgae at concentrations of 15 to 150 ppb, as were their water-soluble extracts. These acute toxicity studies were conducted to determine the relative sensitivity of various organisms to each of the major classes of pollutants and to establish the concentration range for subsequent sublethal studies.

General implications resulting from the CEPEX project indicate that all the pollutants introduced to the experimental containers show similar first effects on the organisms present. Specifically, the effects of metals and petroleum on bacteria are transient and short-term owing to the population's rapid adaption (within days) to imposed stress. Phytoplankton also adapt to stress quickly (less than 15 days). In mixed populations of bacteria and phytoplankton, measures of standing crop (chlorophyll, ATP, carbon) and rate functions (carbon-14 and nutrient uptake kinetics, etc.) provide little information on the effects of pollutants at the ecosystem level.

Some physiological measurements (respiration, excretion rates) show little relation to pollution stress in zooplankton. Other indices of metabolic well-being (egg production, feeding rate) are sensitive indicators of stress at sublethal levels. In general, small zooplankton, regardless of species, are more sensitive than larger organisms (excepting jellyfish). The consequences of pollution on higher trophic levels, for the most part, remains unsolved.

Initial experiments were carried out in 1973 using ¼-scale cylindrical enclosures (2.44 by 15.85 m) to test the engineering feasibility and scientific soundness of the approach. Test results were encouraging, and in 1974 a full-scale model (10.06 by 29.26 m) was deployed for engineering field tests

Table 4.—U.S. institutions, investigators, and projects in Biological Effects Program

Organization	Investigator	Project title
University of Alaska	D. K. Button Reichardt	Lability of Aromatic Hydrocarbons and Their Nonlethal Effects on Marine Organisms
University of California, Scripps Institution of Oceanography	T. J. Chow	Assimilation of Lead, Cadmium, and Thallium by Marine Organisms With Consideration to Biological Effects
Florida State University	J. A. Calder	Investigations of Breakdown and Sublethal Biological Effects in Trace Petroleum Constituents in the Marine Environment
University of Georgia, Skidaway Institute of Oceanography	R. F. Lee	Fate of Petroleum Hydrocarbons in Marine Food Web
Texas A&M University	J. M. Neff	Sublethal Effects of Selected Heavy Metals and Organic Compounds on Organisms From the Gulf of Mexico
	C. S. Giam	Biological Effect of Phthalates and Chlorinated Hydrocarbons in Biota From the Gulf of Mexico
	W. M. Sackett	Fate and Spatial and Temporal Distribution of Petroleum-Derived Organic Compounds in the Ocean, and Their Sublethal Effects on Marine Organisms
University of Texas, Marine Science Institute	J. A. C. Nichol C. Van Baalen	Marine Petroleum Pollution: Biological Effects and Chemical Characterization

Table 5.—U.S. institutions, investigators, and projects in Controlled Ecosystem Pollution Experiment (CEPEX)

Organization	Investigator	Project title
University of Alaska, Marine Science Institute	J. J. Goering A. Hattor	Nitrogen and Silicon Regeneration in Controlled Aquatic Ecosystems
University of California at San Diego, Institute of Marine Resources	J. R. Beers	The Role of Microzooplankton in an Environmental Effects Program
	R. W. Eppley	Kinetics of Nutrient Assimilation by Phytoplankton
University of California, Scripps Institution of Oceanography	O. Holm-Hansen W. H. Thomas F. Azam	Effects of Pollutants on Marine Phytoplankton and Bacterial Communities
University of Georgia, Skidaway Institute of Oceanography	D. W. Menzel	Integrated Field Studies and Operations
	H. L. Windom	Heavy Metal Variations in Natural and Polluted Ecosystems
University of Miami, Rosenstiel School of Marine and Atmospheric Science	M. R. Reeve	The Role of Zooplankton in an Environmental Effects Program
Woods Hole Oceanographic Institution	G. W. Grice	Zooplankton Population Assessment
	R. F. Vaccaro	The Complementary Role of Heterotrophic Microbial Measurements in an Environmental Effects Program

that were continued until early 1975.

During the engineering feasibility studies, scientists conducted experiments on the effects of selected pollutants on ecosystems. Plankton trapped inside the enclosures went through an ecological sequence common to waters surrounding the enclosures. The experiments using ¼-scale enclosures included measuring the effects of low concentrations of copper, mercury, and petroleum hydrocarbons. The results of the copper experiment showed that low concentrations (10 and 50 ppb) of copper caused an immediate mortality of zooplankton species, followed by the development of bacterial and plankton populations that appear to tolerate low-level copper concentrations. The mercury experiments were similar to those of copper. Mercury, however, was toxic to these organisms at lower concentrations (0.25 to 1.0 ppb) and the effects were not as rapidly detectable as those of copper. One interesting result was that bacteria exposed to either copper or mercury showed an increased tolerance to the other metal.

Preliminary findings from the petroleum hydrocarbon experiments were more striking than those from the copper experiments. At low concentrations of petroleum hydrocarbons (approximately 10 to 200 ppb) there was an enhancement of primary productivity among certain marine organisms. However, more recent studies have shown that water extracts of fuel oils at concentrations between 40 to 60 ppb caused a rapid population decrease followed by species shifts in these lower tropic levels. The research suggests that the hydrocarbon concentration in the water column decreases within a few days after introduction. This could be the result of the absorption of these compounds to particulate matter, including dying plankton, which carries them to the bottom where they are degraded by bacteria in the sediment. Certain phytoplankton, (microflagellate and pennate diatom species) show tolerance to the fuel oils used and rapidly increase in numbers when less tolerant species (diatoms) die off.

Efforts are being made to separate the effect of pollutants on plant populations from the effects caused by changes in grazing pressure and predatory stress on grazers. At present CEPEX is not considering the effects of pollutants on benthic organisms.

Biological Effects Data

Results of biological effects studies submitted to NOAA Environmental Data Service's National Oceanographic Data Center follow.

NODC Accession No.: 76–0377
Organization: Skidaway Institute of Oceanography
Investigator: D. W. Menzel
Project title: CEPEX: Integrated Field Studies
Grant No.: IDO73–09763

Data report: Controlled Ecosystem Pollution Experiment (CEPEX) Reduced Data Report No. 1, Mercury Experiment, June 2-July 14, 1975. This report contains background environmental data collected in the vicinity of the experimental enclosures, as follows: depth, temperature, salinity, phosphate, silicate, ammonia, nitrate, nitrite, chlorophyll-a, primary production, and total available photosynthetic quanta.

Pollutant Transfer and Biological Effects Bibliography

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Duce, R. A., G. L. Hoffman, and W. H. Zoller. 1975: Atmospheric trace metals at remote Northern and Southern Hemisphere sites—pollution or natural? *Sci.* 187:59–61.

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Environmental Forecasting Program

Long-range and accurate environmental forecasting requires knowledge of the processes and mechanisms of the oceans and the coupling of the ocean and the atmosphere. The Environmental Forecasting Program focuses on projects designed to explain the large-scale, long-term behavior of the ocean and the ocean's influence on weather and climate. Experiments and studies include: the Joint U.S.-U.S.S.R. Mid-Ocean Dynamics Experiment (POLYMODE); the North Pacific Experiment (NORPAX); the International Southern Ocean Studies (ISOS); and the Climate: Long-range Investigation, Mapping and Prediction Study (CLIMAP).

MODE

Midocean Dynamics Experiment (MODE)

The MODE project of the United States and the United Kingdom has been joined with the U.S.S.R. POLYGON project in a large-scale midocean dynamics experiment, POLYMODE.

Joint U.S.-U.S.S.R. Midocean Dynamics Experiment (POLYMODE)

The purpose of POLYMODE is t oestablish the dynamics and statistics of mesoscale motions in the ocean, their energy source, and their role in the general circulation of the ocean. POLYMODE is based on the U. S.S.R. POLYGON project—a continuing series of experiments investigating mesoscale phenomena in the Atlantic and Pacific Oceans and in the Arabian Sea—and the MODE project of the United States and the United Kingdom. The POLYMODE experiment is under the direction of a Joint U.S.-U.S.S.R. POLYMODE Organizing Committee, established under the Agreement between the Governments of the United States and the U.S.S.R. on Cooperation in Studies of the World Ocean. Other countries have been invited to participate in POLYMODE by the UNESCO/International Oceanographic Commission's Scientific Committee on Oceanic Research (SCOR) Working Group 34.

Figure 1 is a series of maps based on MODE-I data. Figures 2 and 3 show the location of current meter measurements made as a part of the MODE-I, POLYGON, and POLYMODE projects to date. Results of these experiments are summarized as follows:

1. There is an oceanic eddy (variability) field with definable time and length scales.
2. The eddy field is ubiquitous and normally highly energetic relative to the mean general circulation.
3. The eddy field is highly inhomogeneous on a gyre scale—energy levels vary by at least two orders of magnitude and vertical, horizontal, and spatial scales vary to a lesser extent. At a superficial level at least, no one region can be described as "typical."
4. In some regions, the eddy field is inhomogeneous over scales comparable to the eddies themselves.
5. The local dynamics of eddies are indistinguishable from geostrophic assumptions; in general, the dynamics are consistent with quasigeostrophic assumptions.
6. Numerical models with sufficient resolution produce significant eddy activity with realistic scales.

Based on these results, the scientific objectives for the U.S. POLYMODE project are:

1. To carry out field observations and experiments, primarily in open ocean regions of the western North Atlantic, designed (as far as possible) to advance our knowledge of the kinematics and dynamics of the variability in that region and to determine its role in the circulation of the North Atlantic subropical gyre; and
2. To pursue theoretical/numerical modelling of the phenomenon and to apply state-of-the-art theory to the design and rationalization of the POLYMODE field data via both local forecast-process numerical models and high resolution numerical models of the North Atlantic gyre general circulation.

United States participation in POLYMODE is jointly funded by the Office of Naval Research and the National Science Foundation. This participation consists of coordinated research projects that range from field experiments through theoretical studies.

POLYMODE Field Experiments

Two main types of observational activity have emerged: (1) a study of the statistics of eddy motion in different geographical areas and (2) a local dynamics experiment. The former is necessary because no one region seems to be representative of the full complexity of eddies over the entire ocean basin, and because dynamically different regions are known to exist. The latter is necessary because one needs to penetrate deeply into the dynamical balance and machinery of a few eddies. These two directions are the main task of POLYMODE, and this is called the "U.S. Core Program."

There are many aspects of the eddy problem which are important and which lie outside the above tasks and on which important related research may occur independently. It is important to maintain communication, limited coordination, data exchange, and the opportunity for mutual scientific participation with such programs. These are refered to as "Complementary Programs of POLYMODE." Elements of program activities follow.

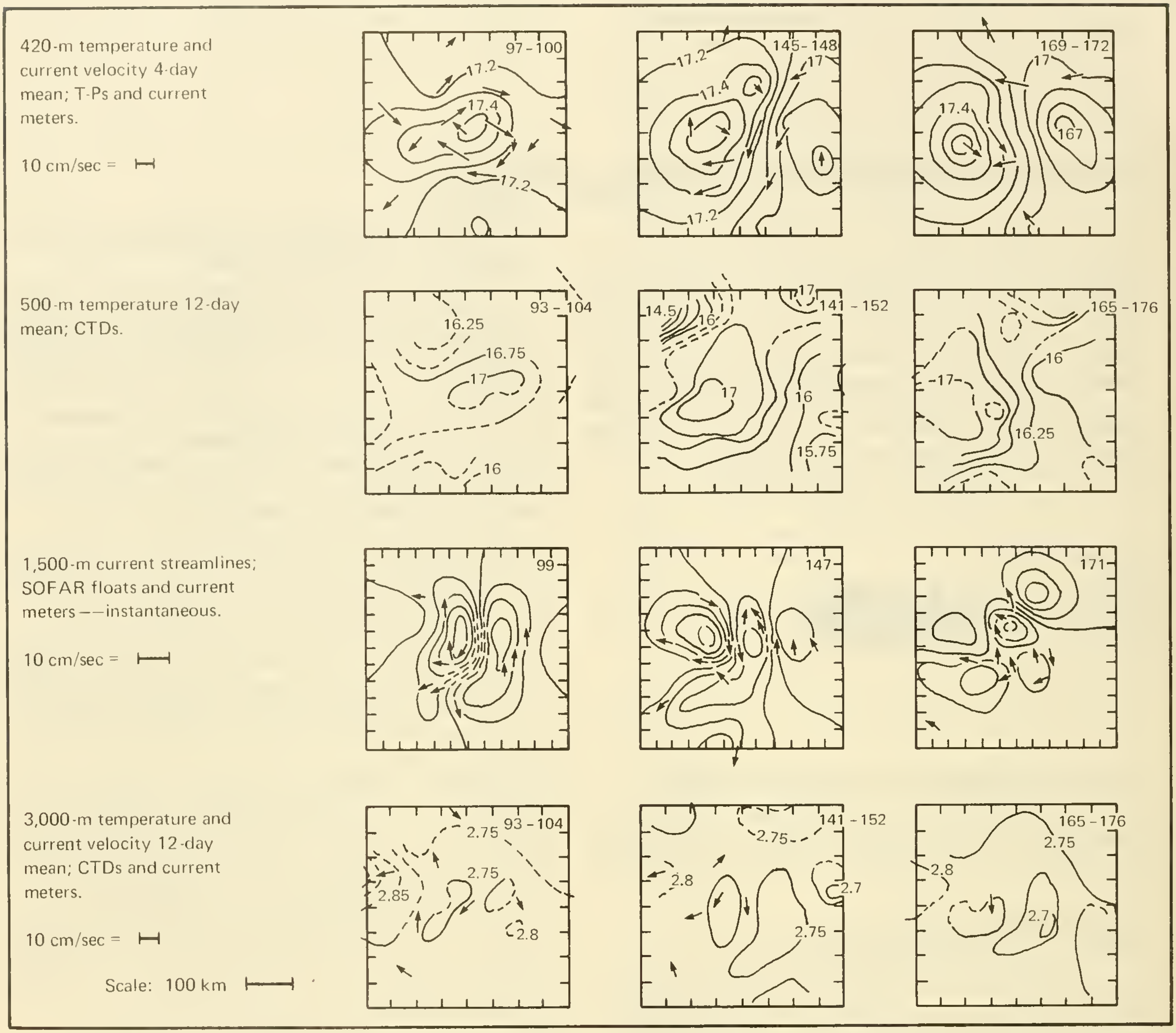

Figure 1.—MODE–I temperature and current patterns at selected depths and intervals of several weeks. Grid is centered at 28 N, 69 40′W.

Elements of U.S. Core Program

(1) *Statistical-Geographical Experiment.* The backbone of this experiment is a consecutive series of three arrays of moored instrumentation in the western North Atlantic: Array I, 7 moorings, starting July 1974, for 9 months; Array II, 12 moorings, starting April 1975, for 27 months; and Array III, 14 moorings, starting July 1977, for at least 12 months. These arrays are located in different regions (one to the east of the Mid-Atlantic Ridge), and designed to embrace a range of scales. They will carry VACM current meters, and T/P recorders (for measurement of current, temperature, and pressure). Data for statistical analysis will also be available from the Northern and Southern Local Dynamics Experiments.

Specially obtained XBT sections will also be made over a wide region of the North and South Atlantic for better resolution of geographical variability of the eddy field as seen in the upper-layer temperature field.

(2) *Local Dynamics Experiment: Southern Synoptic Experiment.* In the spring of 1977, probably over the Nares Abyssal Plain (north of Puerto Rico), a program of mapping of the eddy field will be conducted over an area about 300 km square. The main instrumentation will consist of 60 free-floating, neutrally buoyant (at prescribed depths) SOFAR floats at two levels. After release they will float freely, being tracked acoustically from land-based listening stations. They have a telemetering capability for temperature and pressure and thus provide a nearly real-time map of the flow field. Experience with past float performance indicates that once emplaced, the dispersal will allow the floats to be tracked continuously for up to 3 years. During the first year they will be maintained in a mapping array by recovery and resetting.

During the summer of 1977, an intensive density mapping will also be conducted in this area, using CTDs (to measure salinity, temperature and pressure) for about 40 days. Two U.S. and two U.S.S.R. ships will be involved in an effort to describe the structure of the flow over several eddies, to reveal fine scale features of the flow, and to obtain local dynamical balances via objective mapping techniques.

Elements of the Complementary Program

(1) *Local Dynamics Experiment: Northern Synoptic Experiment.* The U.S.S.R. will maintain for 10 months, starting in Summer 1977, 19 surface moorings with current meter instrumentation at five levels down to 1,500 depth, with extensive density sampling from research vessels, near 35°N, 43°W. The moorings will be deployed in a multiantenna array. U.S. participation will include some part of Array III (mentioned above), technical contributions to the U.S.S.R. mooring system, and possibly a supply of XBTs to enable the density-temperature program sampling to be optimized.

(2) *Eastern Basin Mooring Sites.* The United Kingdom, Federal Republic of Germany, and France will deploy about seven instrumented moorings for up to 2 years in the northern half of the Eastern North Atlantic basin, for gathering statistics over a wide geographical region.

(3) *Neighborhood of the Gulf Stream.* A pilot experiment to study downstream scales of Gulf Stream meanders using deep mooring and inverted echo sounders is planned. Three moorings (Canada) will be maintained north of the Stream. Detailed studies of Gulf Stream rings are also scheduled.

(4) *Small-Scale Processes.* Evidence of coupling of the POLYMODE eddies with high frequency and microstructure phenomena is to be studied further through several small experiments.

(5) *Near-Surface Experiments.* Thirty satellite-tracked drifters with thermistor chains will be launched in the Bay of Biscay (France). An experiment with free-drifting cyclesondes (for obtaining vertical profiles of velocity) has been proposed for the region of the Southern Local Dynamics Experiment. Satellite surveillance by infrared thermometry and microwave altimetry, for remote temperature, sea-state, and surface geopotential topography have been proposed.

(6) *Near-Bottom Experiments.* Modern general circulation numerical models suggest it is important to study the connection of bottom mixed-layer dynamics with that of the overlying low frequency eddy phenomena, and the coupling with bottom topography during POLYMODE. Small arrays of bottom instruments are planned.

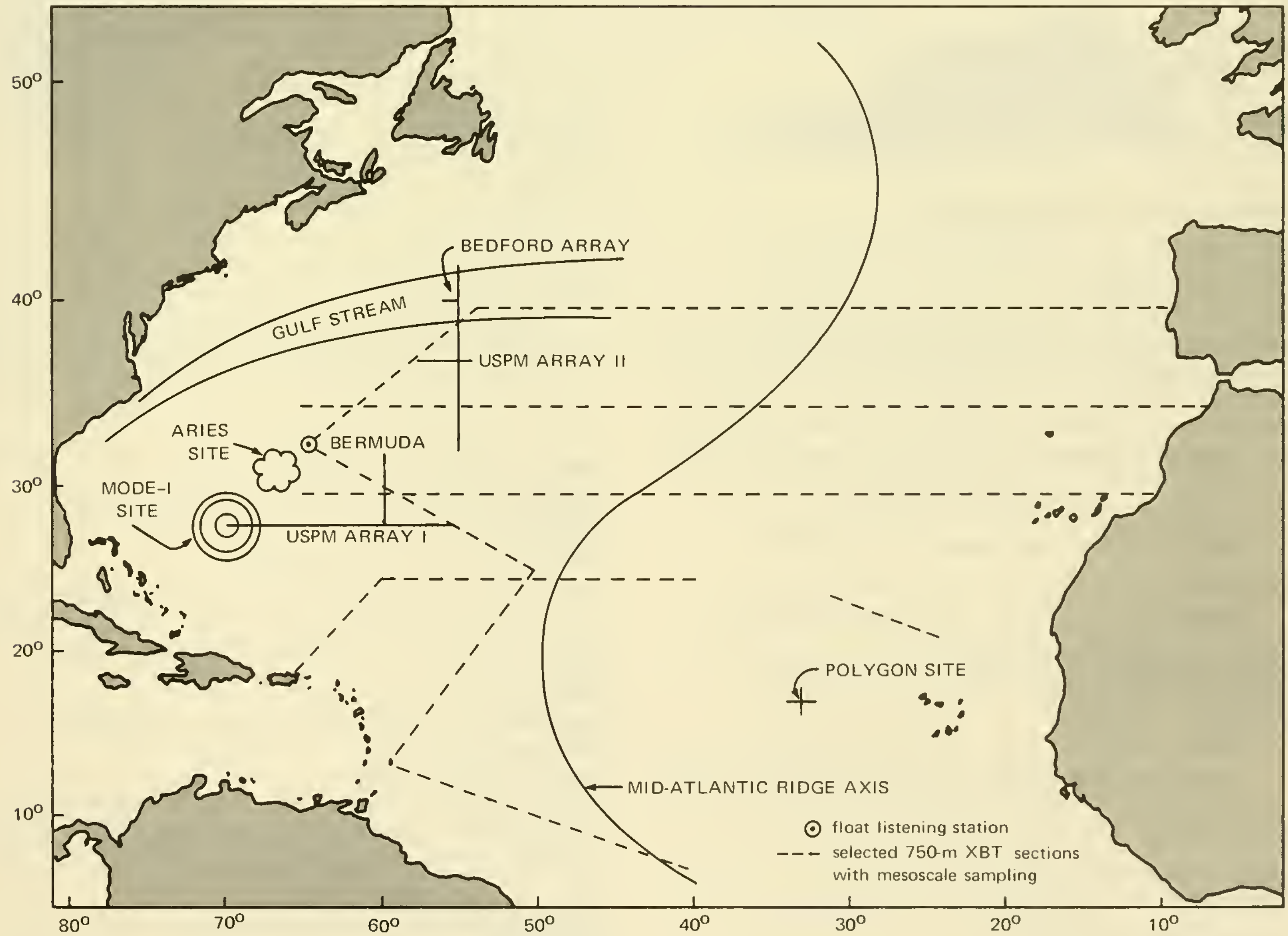

Figure 2.—Mesoscale experiments prior to spring 1976.

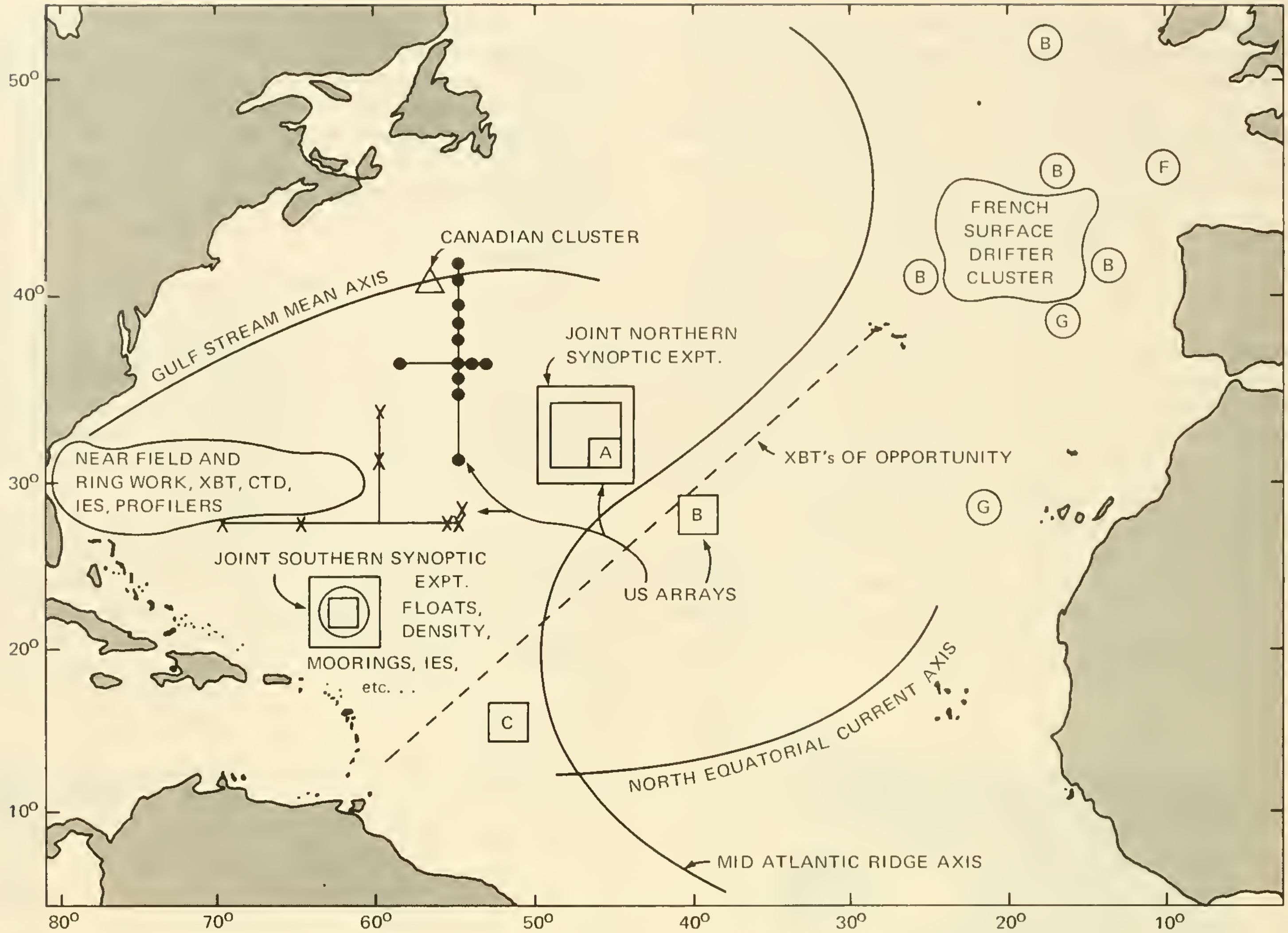

Figure 3.—POLYMODE experiments.

Theoretical Program

The U.S. Core Program also contains substantial theoretical and numerical modelling elements, and U.S. theoreticians and modellers are actively engaged in the exchange of ideas and techniques with colleagues from the U.S.S.R. and other nations. The theoretical program is necessarilly broader that the field experimental program, and involves fundamental investigations, numerical model developments, intercomparison and verification, and dynamical analysis of field data.

Table 6 lists U.S. participants in POLYMODE.

MODE Data

MODE data are available from NODC as follows:

NODC Accession No.: 75–0727
Organization: Massachusetts Institute of Technology
Investigator: C. Wunsch
Grant No.: GX–29034

Temperature and pressure data from MODE moorings; 35 files; December 13–14, 1973, and April 19–21, 1974; magnetic tape.

NODC Accession No.: 75–0761
Organization: NOAA Atlantic Oceanographic and Meteorological Laboratories
Investigator: A Leetmaa
Grant No.: AG–385

660 XBT analog traces (digitized by NODC). Section 1, RV Oceanographer, February 27–March 8, 1974; Section 2, RV Oceanographer, May 11–15, 1974; Section 3, RV Oceanographer, June 6–14, 1974; and Section 4, RV Researcher, September 26–October 7, 1974.

NODC Accession No.: 76–0732
Organization: Woods Hole Oceanographic Institution
Investigator: T. Sanford
Grant No.: (Office of Naval Research)

Current measurements from an electromagnetic velocity profiler; 777 data sets; RV Chain, cruise 122, Legs 4 and 5, May 11 to 27 and June 6 to 13, 1973; magnetic tape.

NODC Accession No.: 75–1005
Organization: Massachusetts Institute of Technology
Investigator: C. Wunsch
Grant No.: IDO74–24095

Temperature and pressure data from MODE moorings: 15 files containing a maximum of 183,750 observations, July 28, 1974–May 15, 1975. Magnetic tape.

NODC Accession No.: 76–0779
Organization: University of Rhode Island
Investigator: D. R. Watts

Grant No.: GX–30416

Inverted echo sounder data from MODE bottom-moored instruments: seven instrument sites; travel-time data from ocean bottom to surface and return at 4-minute intervals; March 19 to July 3, 1973. Punch cards.

The following MODE data listing, cited in IDOE Progress Report Volume 4, is repeated to correct the accession number and add the NODC cruise number:

NODC Accession No.: 74–00724
Organization: Harvard University
Investigator: A. R. Robinson
Grant No.: GX–29033

MODE data: 103 analog copies of XBT traces from Leg 5 of the RV Chain cruise 112, June 6 to 13, 1973. Data are available in digital form; NODC Cruise No. 045198.

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Table 6.—U.S. institutions, investigators, and projects in POLYMODE experiment

Institution	Principal Investigator	Project
University of California, Los Angeles	Y. Mintz	Role of Mesoscale Eddies in the Oceanic General Circulation
University of California, San Diego	R. E. Davis M. C. Hendershott	Statistical Properties and Predictability of Quaisigeostrophic Ocean Flow Models
Harvard University	A. R. Robinson	Analytical and Numerical Studies of Mesoscale Motion
Massachusetts Institute of Technology	H. Huppert V. Lee H. Stommel	Topographically Generated Currents MODE-I Atlas
	H. Stommel W. Simmons R. Heinmiller	Coordination, Planning, Workshops, Communications, and Administration
	C. Wunsch	Participation in POLYMODE
University of Rhode Island	H. T. Rossby	A Synoptic Study of Barotropic and Baroclinic Eddies in the Ocean
U.S. Naval Academy	L. Dantzler	An Evaluation of Mesoscale Oceanic Eddy Statistics from both Historical and Ship-of-Opportunity XBT Data
Woods Hole Oceanographic Institution	D. Bitterman, Jr. W. S. Schmitz, Jr.	Inverted Echo Sounder Development Program
	N. P. Fofonoff	An intercomparison of U.S., and U.S.S.R. Moorings,
	W. J. Schmitz, Jr.	Current Meters, and Conductivity-Temperature-Depth Instruments
	N. P. Fofonoff W. J. Schmitz, Jr.	An Observational Study of the Dynamics of Mesoscale Eddies and their Role in the Circulation of the North Atlantic Ocean
	P. L. Richardson	Cyclonic Gulf Stream Rings in the Sargasso Sea
	P. B. Rhines	Energy Propagation, Fine Structure and Local Dynamics of Oceanic Eddies and Waves
	D. C. Webb	Float Project
	F. Webster	Newsletter

NCAR Electra at Kodiak, Alaska, March 1975. NORPAX flights over ocean in regimes of high wind speed directly measure air-sea flux of heat, momentum, and moisture by means of instruments mounted on nose boom.

Bretherton, Francis. 1975: Recent developments in dynamical oceanography, *Quarterly J. Royal Meteor. Soc.* 101(430): 705–721, MODE Contribution No. 42.

Brown, W., W. Munk, F. Snodgrass, H. Mofjeld, and B. Zetler. 1975: MODE bottom experiment, *J. Phys. Oceanog.* 55(1):75–85.

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buoyant floats in the North Atlantic, *J. Mar. Res.* 33(3): 383–404, MODE Contribution No. 40.

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McWilliams, James. 1975: Large scale inhomegenity and mesoscale ocean waves: A single stable wave field, *J. Mar. Res.* 23(4):285–300, MODE Contribution No. 35.

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Gifford, James E. 1975: Cruise Report, ATLANTIS-II, Tech. Rep. WHOI–74–103, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, 19 pp.

Gifford, James E. 1975: Cruise Report, KNORR 26. Tech. Rep. WHOI–74–104, 41 pp.

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Olbers, Dirk Jurgen. 1974: On the energy balance of small-scale internal waves in the deep-sea, Hamburger Geophysikalische Einzelschriften, Hamburg, G.M.L. Wittenborn Sohne 2 Hamburg 13, 91 pp.

North Pacific Experiment (NORPAX)

The long-term objective of NORPAX is to understand fluctuations in the upper layers of the North Pacific Ocean and their relation to the overlying and adjoining atmosphere. These fluctuations have time scales of months to years and a space scale in excess of 1,000 km. Achievement of this goal should lead to improved prediction of weather and climate for the northeast Pacific Ocean and North America. NORPAX is jointly sponsored by IDOE and the Office of Naval Research. Principal investigators and projects are listed in table 7.

NORPAX is working to attain its long-range objective through analysis of historical data, experiments to identify and understand important processes, monitoring of low-frequency fluctuations, and integration of observations with theoretical studies. NORPAX experiments in the past year include El Niño watch and the TRANSPAC project.

El Niño Watch

To describe the occurrence of the El Niño, and its development with time, the ocean off western South America to 95°W and from 14°S to 2°N was surveyed during mid-February through March and mid-April through May 1975 (figs. 4 and 5). The University of Hawaii research vessel MOANA WAVE was used to obtain vertical profiles of temperature and salinity to a depth of 500 m at stations 60 nmi apart; XBT temperature profiles at 20-nmi intervals; and hydrographic stations at 120-nmi intervals, including bottle casts for oxygen and nutrients. In addition, zooplankton and phytoplankton samples were obtained, and primary productivity and chlorophyll-A were measured. Twice-daily upper air observations were collected by a U.S. Navy team using radiosondes, and surface meteorological observations were recorded at 2-hour intervals. Personnel aboard the RV MOANA WAVE represented Scripps Institution of Oceanography, University of Hawaii, Duke University, University of Washington, Instituto del Mar del Peru, Instituto Oceanografico de Ecuador, and the U.S. Navy.

During the first cruise southeast trade winds were extremely weak north of 10°S. In the ocean, warm, low-salinity water was observed to transgress south across the Equator to 5°S (fig. 6a). Although weak upwelling was still present along the coast of northern Peru, cool water was not advected northwest from this upwelling region as in normal years. The warm

Table 7.—U.S. institutions, investigators, and projects in NORPAX program

Organization	Investigator	Project title
University of Alaska	T. C. Royer	Circulation and Heat Content Fluctuations in the Gulf of Alaska
University of British Columbia	M. Miyake	Air-Sea Interaction Study with Aircraft
California Institute of Technology, Jet Propulsion Laboratory	M. T. Chahine	Remote Sounding of Temperature of the Ocean Surface in Cloudy Atmosphere
University of California, San Diego	C. A. Friehe	Measurement of Surface Fluxes of Heat, Water Vapor, and Momentum from Aircraft and Merchant Ships
University of California, Scripps Institution of Oceanography	T. P. Barnett	Temperature Velocity Structure Study
	R. L. Berstein	Feasibility Study for use of Satellite Data in NORPAX
	R. L. Bernstein	Low-Frequency Baroclinic Responses of the North
	W. B. White	Pacific Current to Interannual Variability in the Westerly Winds
	R. E. Davis	Upper Ocean Dynamics
	M. C. Hendershott	A Model Study of Large-Scale Ocean-Atmospheric Interaction
	K. E. Kenyon	Large-Scale Dynamics of the Upper Ocean in the Pacific
	G. J. McNally	Satellite Tracked Drifting Buoys
	W. C. Patzert	Analysis and Publication of El Niño Cruise Data
	J. Namias T. P. Barnett	Large-Scale and Long-Term Air-Sea Interaction Over the Pacific and Remote Weather and Climate Influences
	R. T. Wert	NORPAX Data Program
	R. T. Wert	NORPAX Administration and Travel
	W. B. White	Year-to-Year Variability in the Thermal Structure of the Subtropical Gyre in the Western North Pacific Ocean
	W. B. White R. L. Bernstein	Hydrographic Measurements of the North Pacific Current
University of Hawaii	L. Magaard W. Emery	Baroclinic Rossby Waves in the North Pacific
	M. J. Vitousek	Line Islands Monitoring
	K. Wyrtki	Interaction of Circulation, Sea Level, Heat Storage, and Winds Over the Pacific Ocean
	K. Wyrtki	El Niño Watch
	J. C. Sadler	North Pacific Cloudiness and Cloud Anomalies from Satellite Observations

Table 7.—U.S. institutions, investigators, and projects in NORPAX program—continued

Organization	Investigator	Project title
University of Michigan	J. C. K. Huang	Numerical Simulation of El Niño Phenomenon Fluctuations in the Pacific
National Marine Fisheries Service NOAA	D. R. McLain J. F. T. Saur	Time Series XBT Sections, Equatorial and Northeast Pacific Ocean
Naval Fleet Numerical Weather Central	C. R. Ward K. Wyrtki	Continuance of Ships of Opportunity Program
Naval Postgraduate School	R. L. Haney	Numerical Simulation of Coupled North Pacific Ocean-Atmospheric System
Naval Research Laboratory	H. E. Hurlburt J. D. Thompson S. A. Piacsek K. Wyrtki	A Numerical Investigation of the Time Dependent Circulation of the Equatorial and Eastern Pacific
Oregon State University	H. Crew P. P. Niiler	Pilot Study of Precipitation in the North Pacific Investigations of Long-Period Changes of Ocean Surface Layers
	C. Paulson	Ocean Mixed-Layer Structure
	W. H. Quinn	Large-Scale and Long-Term Fluctuations in the Ocean and Atmosphere Over Lower Latitudes of the Pacific and Their Consequences
San Diego State University	C. Dorman	Variability of Ocean Thermal Structure Between San Francisco and Hawaii
Stanford University	A. M. Peterson G. L. Tyler	Radar Studies of Sea and Decametric Radio-Wave Observations of the North Pacific
Texas A&M University	A. D. Kirwan	Anomaly Dynamics Study
University of Tokyo	H. Solomon	The Role of Subpolar Western Boundary Currents in Large-Scale Air-Sea Interaction in the North Pacific
University of Washington	B. A. Taft	Kuroshio Index; History and Recent Observations

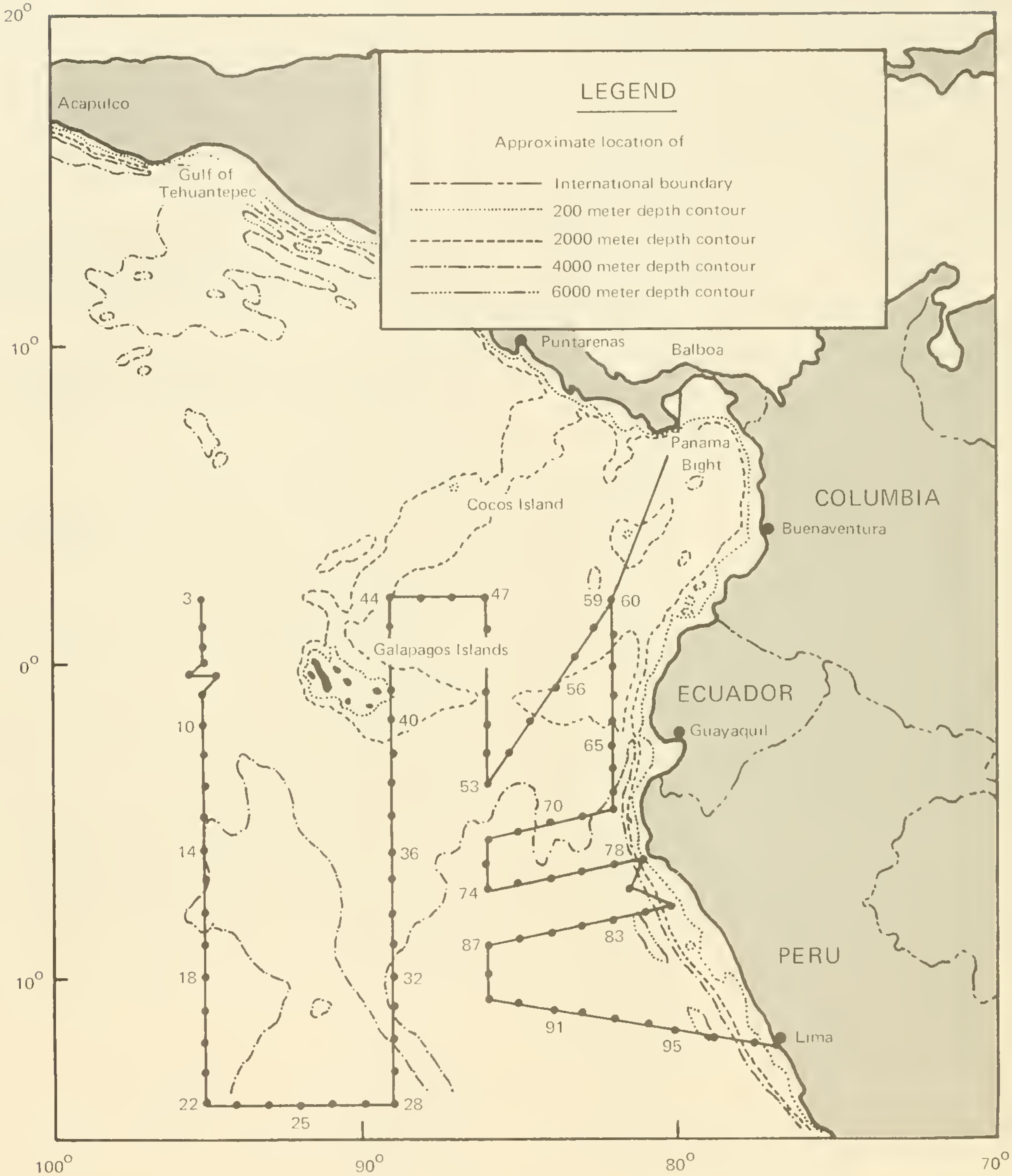

Figure 4.—El Niño Watch legs 1 and 2.

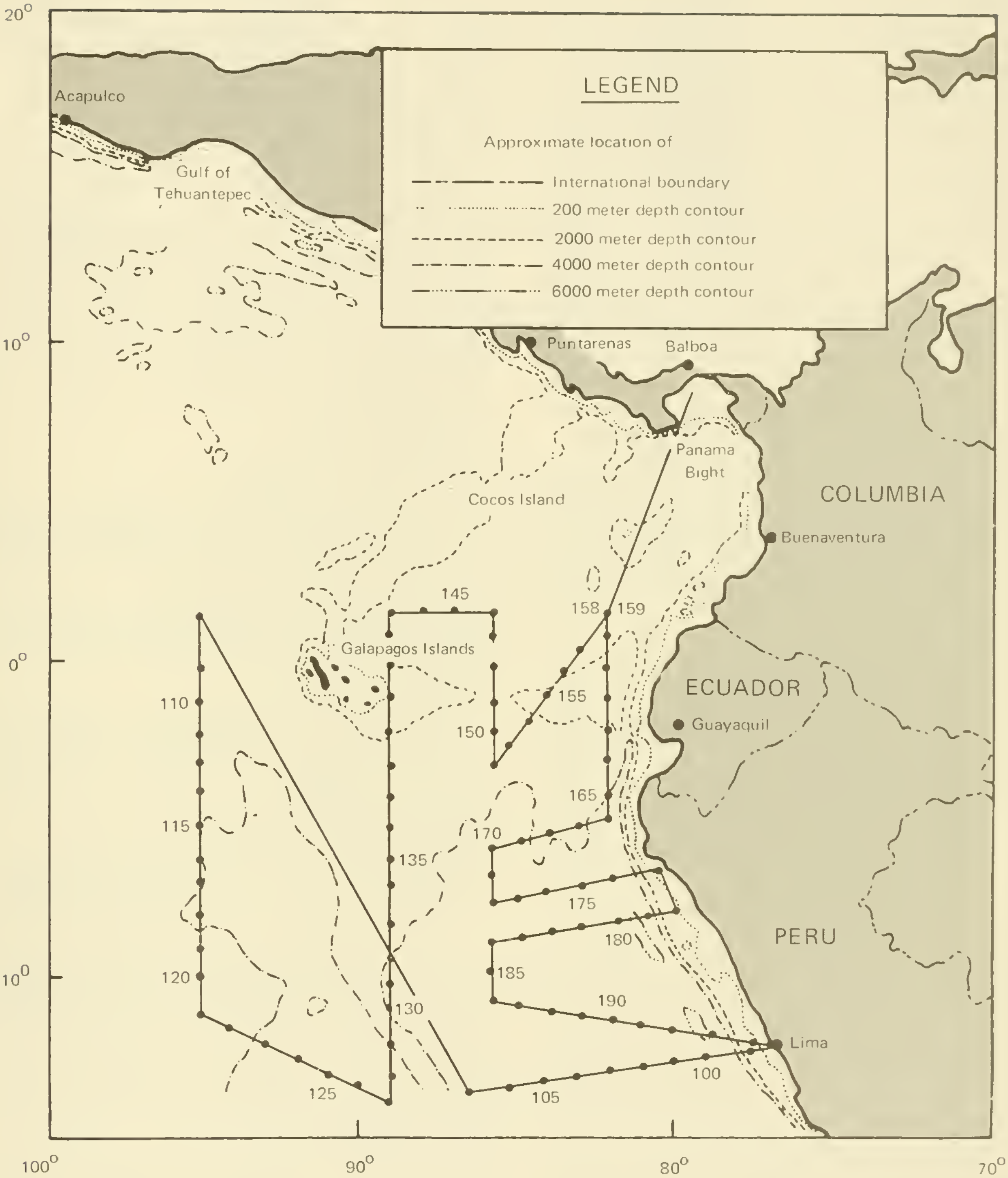

Figure 5.—El Niño Watch legs 3 and 4.

southward flow between the Galapagos Islands and Ecuador was confined to a shallow surface layer 10 to 25 m thick, and changes in the subsurface layers also were quite different from what is normally expected. The density surfaces along both the Equator and the coasts of Ecuador and Peru were abnormally depressed in the upper 200 m, indicating a very strong eastward flow of the Equatorial Undercurrent and a southward flow along the coast. This anomalous flow regime seems to play an important role in El Niño dynamics.

Although observations during the first cruise revealed features of a developing El Niño, the data of the second cruise documented that it was short-lived. During April and May, with the re-establishment of the southeast trade winds, and upwelling along the coast and Equator, the cool waters of the Peru-Chile Current replaced the warm waters found 2 months earlier (fig. 6b). The subsurface flow eastward along the Equator had weakened, and along the coast the subsurface flow was no longer to the south. The large change in sea surface temperature between the time of the two cruises (fig. 6c) illustrates the rapid and intense variation in the ocean in this region. The change in sea surface temperature within this 2-month period (greater than 5°C in some areas) was as large as the mean seasonal range indicated by climatological atlases.

Although 1975 was not the year of a catastrophic El Niño of long duration, an El Niño event continued to develop from January through March. Cruises of previous expeditions never covered the entire affected area. Consequently, much was learned about the dynamics of El Niño events—particularly the generation of large temperature and circulation anomalies and their rapid dissipation.

TRANSPAC

The TRANSPAC program uses observers aboard commercial ships (platforms-of-opportunity) that regularly cross the Pacific Ocean. Data obtained within the area from 30° to 50°N and 140°W to 150°E, which was continuously monitored for the first time, show significant results. One observed phenomenon was the rapid variability of the main thermocline over this large area during a relatively short period (fig. 7). Along two nearly parallel ship tracks separated by about 150 km (TAFT and VAN BUREN voyages), observations were obtained within a 2-day period. Depths of the 10° and 12°C isotherms (which were selected as representative of the main thermocline) agreed very well along the two tracks despite their 150-km separation, indicating a marked uniformity in depth of the main thermocline over the large area traversed by the ships. Along two nearly parallel ship tracks separated by only 20 km (McKINLEY and VAN BUREN voyages), observations were obtained about 12 days apart. Over this period, the 10° and 12°C isotherms were observed to descend about 50 meters, indicating a rapid change in depth of the main thermocline. This change was attributed to passage of a major winter storm slightly north of the two tracks during the 12-day period. An Anomaly Dynamic Study (ADS) has been initiated to investigate such changes in thermocline structure.

NORPAX Data

NORPAX data and information available from NODC include the following.

NODC Accession No.: (none)
Organization: University of Hawaii
Investigator: K. Wyrtki
Grant No.: IDO75–06468

NORPAX/El Niño Watch preliminary data report, Volumes I and II, RV MOANA WAVE, Legs 1 and 2, February 11 to March 31, 1975. Physical, chemical, and biological data: 93 SDT profiles, 45 Niskin casts, 432 XBTs, 97 zooplankton net tows, 74 meteorological balloon soundings, and current meter data. (Data report prepared by GEOSECS Operations Group, Scripps Institution of Oceanography.)

NODC Accession No.: (none)
Organization: University of Hawaii
Investigator: K. Wyrtki
Grant No.: IDO75–06468

NORPAX/El Niño Watch preliminary data report, Volume III, RV MOANA WAVE, Legs 3 and 4, April 17 to May 27, 1975. Physical, chemical, and biological data: 97 STD profiles, 47 Niskin casts, 411 XBTs, 93 zooplankton net trawls, 67 meteorological balloon soundings, and 74 tritium samples.

NODC Accession No.: 76–0615
Organization: NOAA National Marine Fisheries Service, La Jolla, Calif.
Investigator: D. McLain
Grant No.: OCE 75–23357

NORPAX Pacific Ships of Opportunity data: XBTs from 6 ships, 97 cruises; 1,254 lowerings, August to December 1974, and 1,481 lowerings, January to July 1975, magnetic tape.

NODC Accession No.: 74–00748
Organization: NOAA National Marine Fisheries Service, La Jolla, Calif.
Investigator: J. F. T. Saur
Grant No.: AG–256

NORPAX data: 1,460 digitized XBT drops from the Pacific Ships of Opportunity Program during the period April 1973 to July 1974.

NODC Accession No.: 75–0530
Organization: Scripps Institution of Oceanography
Investigator: R. T. Wert, NORPAX Data Manager

NORPAX data: One magnetic tape containing observations from 23 bumble bee buoys (at 1-hour intervals). Parameters are: 1) air temperature, 2) wind speed and direction, 3) wind transport, 4) barometric pressure, 5) sea temperature at maximum of 12 depths, 6) pressures at two depths, 7) solar radiation, and 8) mooring line tension. Data were collected from 6 buoys during May 1964 to February 1967, and from 17 buoys during February 1968 to February 1973.

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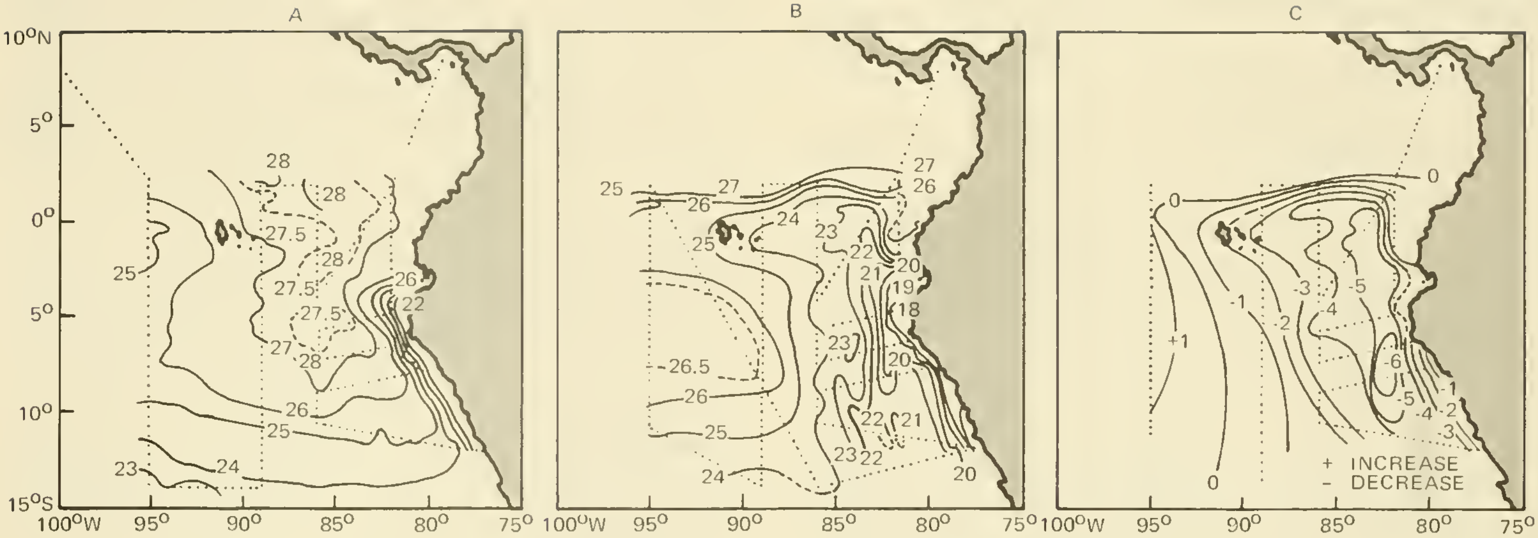

Figure 6.—Temperatures observed during RV MOANA WAVE surveys off western South America in 1975. A, Mid-February through March; B, Mid-April through May; and C, change in temperatures between time of two cruises. Isotherms in degrees Celsius.

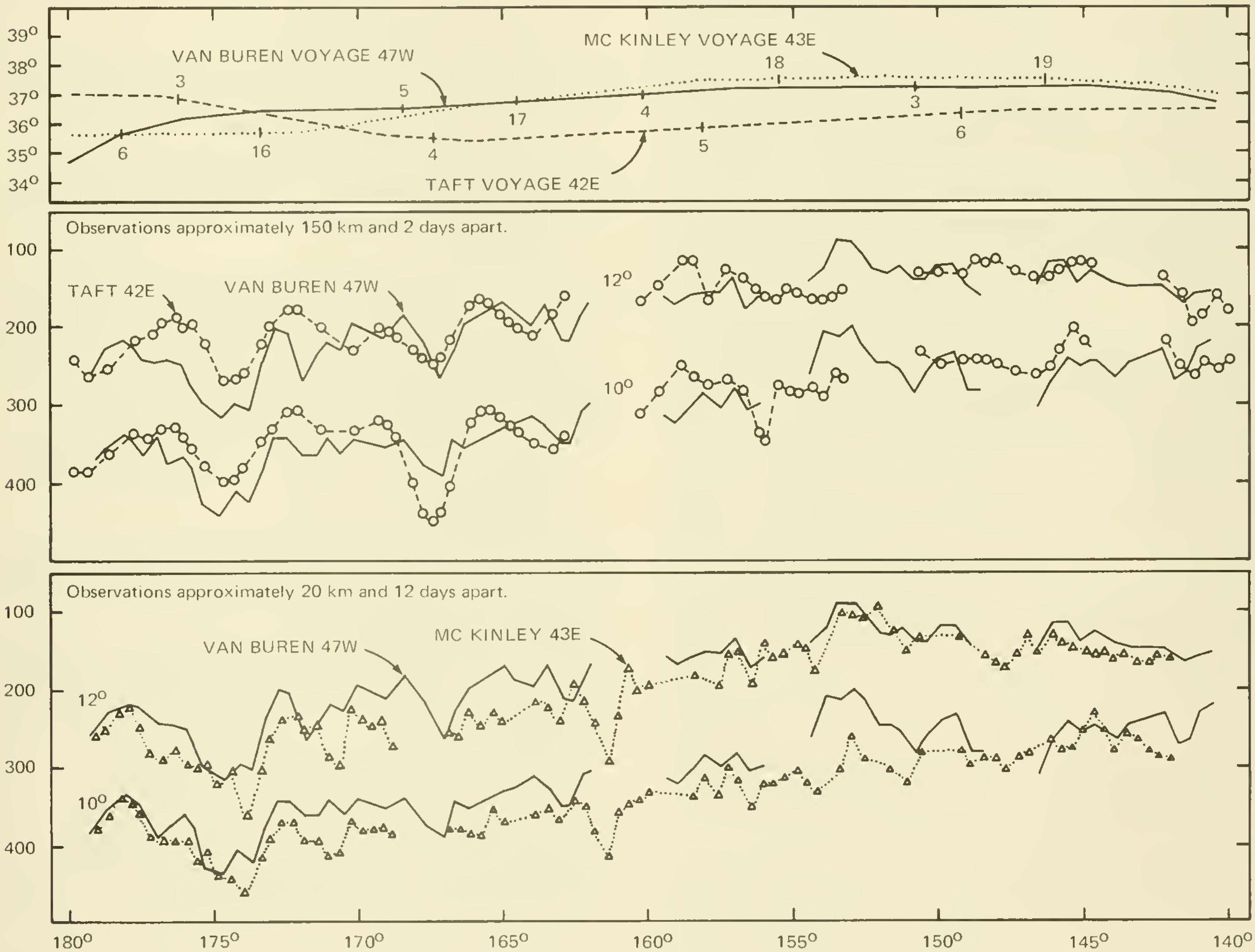

Figure 7.—Ships-of-opportunity observations of seawater temperatures along North Pacific routes. Depths of 10° and 12°C isotherms represent depth of main thermocline.

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International Southern Ocean Studies (ISOS)

ISOS is concerned with understanding the long-term, large-scale variability of dynamical processes in the Southern Ocean. It consists of a series of experiments to determine global atmospheric and oceanic circulation and their interaction. The project has focused on the dynamics of the Antarctic Circumpolar Current, the First Dynamic Response and Kinematics Experiment (F DRAKE), but studies have been made of bottom-water formation and the Polar Front. The long-range scientific objectives of ISOS and F DRAKE cruises are to:

1. Identify space and time scales of the Antarctic Circumpolar Current in the region of the Drake Passage and Western Scotia Sea, an ultimate goal being to design a transport experiment in this region;
2. Obtain a regional description of the Drake Passage — Western Scotia Sea area, including bathymetry, nutrient relationships, and hydrography;
3. Improve our knowledge about the Antarctic Circumpolar Current in the Western Scotia Sea region—specifically to better understand the synoptic features of the current in that region; and
4. Improve our knowledge of the Polar Front, to better understand the dynamics and mixing processes of this oceanic feature.

F DRAKE (First Dynamic Response and Kinematics Experiment)

The first field phase, F DRAKE 75, was January through March 1975. During this period, current and temperature recorders were moored in Drake Passage to study time and space scales in the flow though the Passage. The array of instruments consisted of both long- and short-term moorings. Short-term moorings were recovered at the end of each cruise and yielded information about time scales of less than 20 days. Long-term moorings included two tide gauges and 19 current meters and yielded information regarding time scales of up to 1 year.

Vessels participating in F DRAKE 75 were RV CONRAD of Lamont-Doherty Geological Observatory, RV MELVILLE of Scripps Institution of Oceanography, and ARA ISLAS ORCADAS of the Hydrographic Service of the Argentine Navy. The ORCADAS is participating under an agreement between the National Science Foundation, the Argentine Antarctic Institute, and the Argentine Naval Hydrographic Service. Observations by the three ships included oceanographic stations, expendable bathythermographs (XBTs), and underway oceanographic and meteorological measurements (fig. 8). Special studies by the MELVILLE included occupying oceanographic stations in relation to the locations of moored arrays. Some moored arrays were recovered during F DRAKE 75; the remainder were set as year-long moorings to be recovered during F DRAKE 76. During austral summer 1976 the RV THOMPSON, A.G.S. YELCHO, and RV PROFESSOR VIZE made F DRAKE cruises. *IDOE Progress Report Volume* 4 described general goals and specific objectives of F DRAKE 75.

The second field phase, F DRAKE 76, was scheduled January through March 1976. The first task of F DRAKE 76 was recovery of the first long-term array and deployment of the second year-long array (fig. 9). Recovery, deployment, and supporting hydrographic work were accomplished during Leg I of the THOMPSON cruise. Leg II of the THOMPSON cruise consisted of a closely spaced hydrographic section parallel to the array (the "DRAKE" section) and a second closely spaced section perpendicular to the first (the "1976" section). During Leg II, satellite-tracked drifting buoys were launched and special chemical studies were included in the hyrographic work. Leg III of the THOMPSON cruise was devoted to studying the Polar Front in the region of 58°S, 64°W. Instruments used in this study included CTDs, an O_2 profiler, profiling current meters, thermistor chains, and vertical current meters.

The Chilean Naval vessel YELCHO was used to map the temperature structure in and near the Polar Frontal Zone on two cruise legs of 2 weeks duration. The first leg, which began before Leg III of the THOMPSON cruise, was used to locate and map the Polar Frontal Zone to the east of the moored arrays in Drake Passage. The thermal structure was mapped using XBTs and a satellite navigation receiver. Data were transmitted to the THOMPSON via ATS transceivers aboard the vessels. This made it possible for the Thompson to proceed directly to the study area and concentrate on small-scale measurements. Because the position and configuration of the Polar Frontal Zone

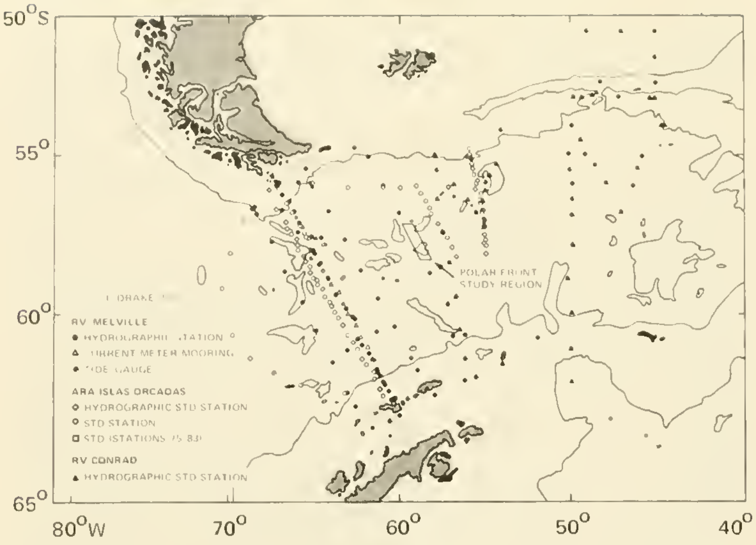

Figure 8.—Oceanographic sampling accomplished during F DRAKE 75.

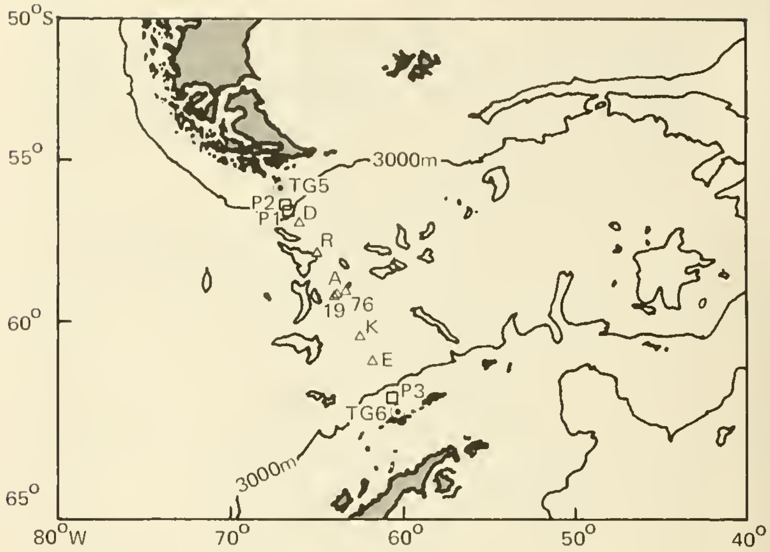

Figure 9.—Location of year-round measurements in Drake Passage during 1976. Triangles are current meter moorings. Each mooring had an Aanderaa current meter at 2,700 m; D, R, A, and E had another Aanderaa current meter at 500 m. Circles TG5 and TG6 are locations of shallow-water Aanderaa tide gauges. Squares P1, P2, and P3 are locations of deep-sea pressure gauges. P2 and P3 were at 500-m depth and P1 at 1,700-m depth.

changes with time, the YELCHO again mapped the thermal structure of the region during the last 2 weeks of the THOMPSON survey. In this manner, investigators were able to obtain a reasonably good picture of the temporal development of mesoscale frontal features.

The PROFESSOR VIZE deployed three current meter moorings in mid-January 1976. These moorings were maintained for about 1 month during an extensive hydrographic survey (fig. 10) that included upper air observations every 6 hours to study the meteorology of the region.

Other Studies

ISOS sponsors individual theoretical studies and regular meetings of a panel on theoretical studies. The studies emphasize circumpolar current dynamics. Included are laboratory investigations, an analytical study of topographically-induced jets in a zonal channel, and analytical studies of the interaction of bottom topography and the circumpolar current. Another ISOS project provides for the publication of a Southern Ocean Atlas. Completion of the Atlas is expected in 1978. Some preliminary plates based on data collected by the ISLAS ORCADAS have been published. In September 1974, an ISOS field project was completed near McMurdo Sound to determnie the feasibility of winter hydrography in the regions of bottom-water formation. Although this project yielded promising results, logistic constraints prevented further measurements.

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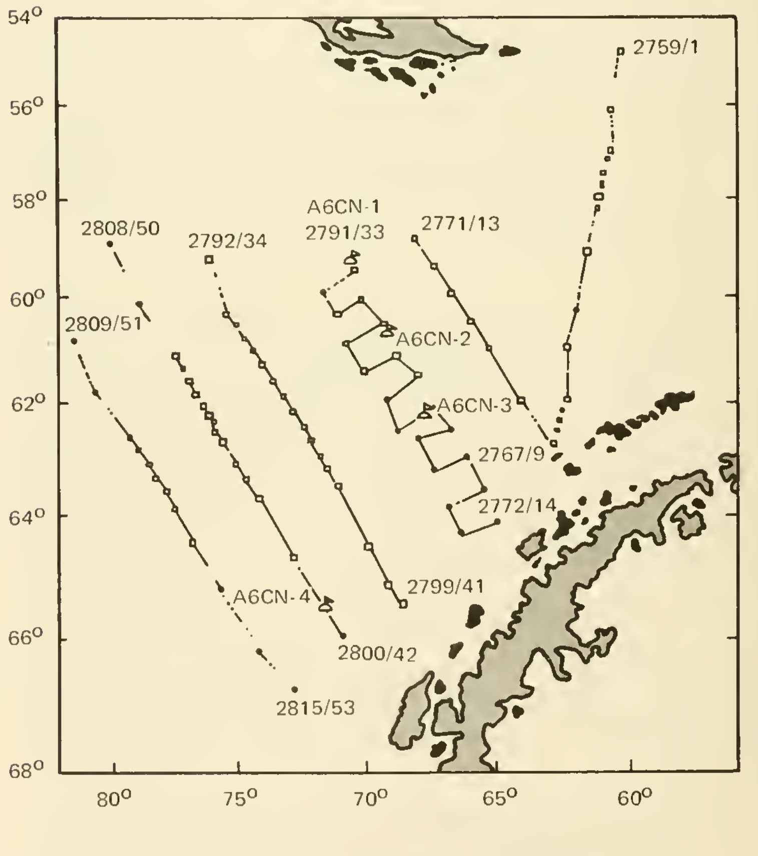

Figure 10.—RV PROFESSOR VIZE oceanographic observations in Drake Passage, January 1976.

Table 8.—U.S. institutions, investigators, and projects in ISOS program

Organization	Investigator	Project title
Columbia University,	A. Gordon	Southern Ocean Atlas
Lamont-Doherty Geological Observatory	A. Gordon S. Jacobs	Investigation of Physical Oceanography of the Northwest Scotia Sea and Falkland Plateau
NOAA Data Buoy Office	J. Winchester	A Pilot Drifting Buoy Experiment in the Southern Ocean
NOAA Pacific Marine Environmental Laboratory	S. Hayes	Circulation in the Upper Waters in the Antarctic Frontal Zone
Nova University	M. Spillane	Quasigeostrophic Zonal Jets
Oregon State University	J. Allen	Theoretical Studies of Time-Dependent Flow in the Vicinity of Drake Passage
	L. Gordon	Chemical Observations and Interrelationships in the Southern Ocean
	R. Pillsbury H. Bryden	Study of the Long-Term Variability of the Antarctic Circumpolar Current in the Drake Passage
Texas A&M University	A. D. Kirwan	Southern Ocean Lagrangian Observations
	W. D. Nowlin	Central Administration, Coordination and Planning
	W. D. Nowlin	Chemical and Physical Oceanography of the Antarctic Circumpolar Current and Frontal Zones: I. Observations in the Drake Passage and Scotia Sea
University of Southern California	T. Maxworthy T. Spence	Laboratory Modelling Studies of the Antarctic Circumpolar Current
University of Washington	D. J. Baker	Coordination of Monitoring Activities and Liaison with the Polar Experiment of the Global Atmospheric Research Program
	D. J. Baker	Theoretical Workshops
	D. J. Baker R. Wearn	Transport Measurements of the Antarctic Circumpolar Current and Analysis of Existing Tidal and Meteorological Data
Woods Hole Oceanographic Institution	T. Joyce	Dynamical Observations at the Antarctic Polar Front
	M. McCartney	Theoretical Modeling of Current-bottom Topography Interactions in the Southern Ocean

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RV Thompson setting current meter mooring in Drake Passage, February 1976

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Climate: Long-Range Investigation, Mapping, and Prediction (CLIMAP) Study

CLIMAP research focuses on describing and explaining climatic changes over the last million years. Accurate descriptions of climatic change over that time scale will improve the CLIMAP scientists' understanding of transitions between what are considered to be the two stable states of global climate—the ice age and temperate periods. These studies will also increase knowledge about mechanisms of climatic change by comparing global climatic descriptions derived from data collection and analyses with those produced by computer models.

A unique aspect of the CLIMAP study is that analyses of deep-sea sediments are used as the primary source of data. Deep-sea sediments are particularly useful as indicators of past climatic conditions for a variety of reasons. 1) They are not geographically restricted, and their global extent adds to their value as climatic indicators since the interchange of heat between the world oceans and the atmosphere plays a dominant role in climatic variations. 2) Deep-sea sediments accumulate at a relatively constant and continuous rate that is uninterrupted for perhaps hundreds of thousands of years. 3) Their multivariate characteristics make possible a wide range of correlative interpretations, including chemical and physical properties, concentrations of microfossils sensitive to differing combinations of surface or sea-bottom environmental factors, isotopic ratios, and other diverse indicators.

Recent advances in CLIMAP research relate to the global climatic reconstruction programs which assemble synoptic records of data to reconstruct past changes and near equilibrium states of the global climate. Scientists at several institutions have formulated a model using quantitative geologic evidence to reconstruct the Earth's surface approximately 18,000 years ago, the time of maximum extent of continental glaciation in the last ice age. Climatic boundary conditions for the reconstruction were continental geography at a time of lowest sea levels, the albedo or light reflectance of glaciated and nonglaciated areas, the extent and elevation of permanent ice, and the sea-surface temperature pattern of the world ocean. Figure 11 shows the reconstructed surface for summer of ice-age earth 18,000 years ago applying the interpreted boundary conditions. Figure 12 shows the difference between August sea-surface temperatures 18,000 years ago and present measurements.

From these reconstructions it can be seen that 18,000 years ago the Earth's surface differed remarkably from present conditions. Huge land-based ice sheets with a corresponding increase in pack ice and marine-based ice sheets covered large areas in the Northern Hemisphere, while sea ice in the Southern Hemisphere showed a greater contrast in extent. The changes in land vegetation with grasslands and deserts spreading at the expense of forests, joined with the expanded areas of permanent ice to cause an increase in global surface albedo and a marked general cooling of the ocean's surface.

The determination of the estimated boundary conditions on the Earth's surface during the maximum extent of glaciation 18,000 years ago has enabled CLIMAP researchers to develop a preliminary model of global atmospheric conditions including such elements as pressure, temperature, wind, cloudiness, and precipitation that enveloped ice-age Earth. The simulation of this model allows preliminary comparisons to be made with available paleoclimatic data, with the result that systematic investigations of paleoclimatic structures can be initiated.

In addition to estimating boundary conditions and developing global atmospheric models, other accomplishments of CLIMAP in the past year include:

1. Preparation of material for a second time-level reconstruction—the penultimate interglacial maximum, 120,000 B.P. (before present).

2. Preparation for final revised 18,000 B.P. reconstruction.

3. Development of techniques in using benthonic fauna to estimate bottom water characteristics.

4. Determination of periodicities in the climatic record that match precisely with periodicities of the Earth's orbital parameters, (eccentricity, obliquity, and precession) during the last half million years.

5. Establishment of a precise chronology for climatic fluctuations in deep-sea cores during the last half million years.

Future CLIMAP research plans are to improve the 18,000-B.P. August sea surface temperature map and to complete the first global map of 18,000 B.P. February temperatures and albedos, providing CLIMAP's first look at seasonal contrasts in the ice-age world. This map will then be made available to various modeling groups at several institutions for development of general circulation models for that time interval. The documentation of global reconstruction of ice sheets at 18,000 B.P. and 120,000 B.P. is continuing.

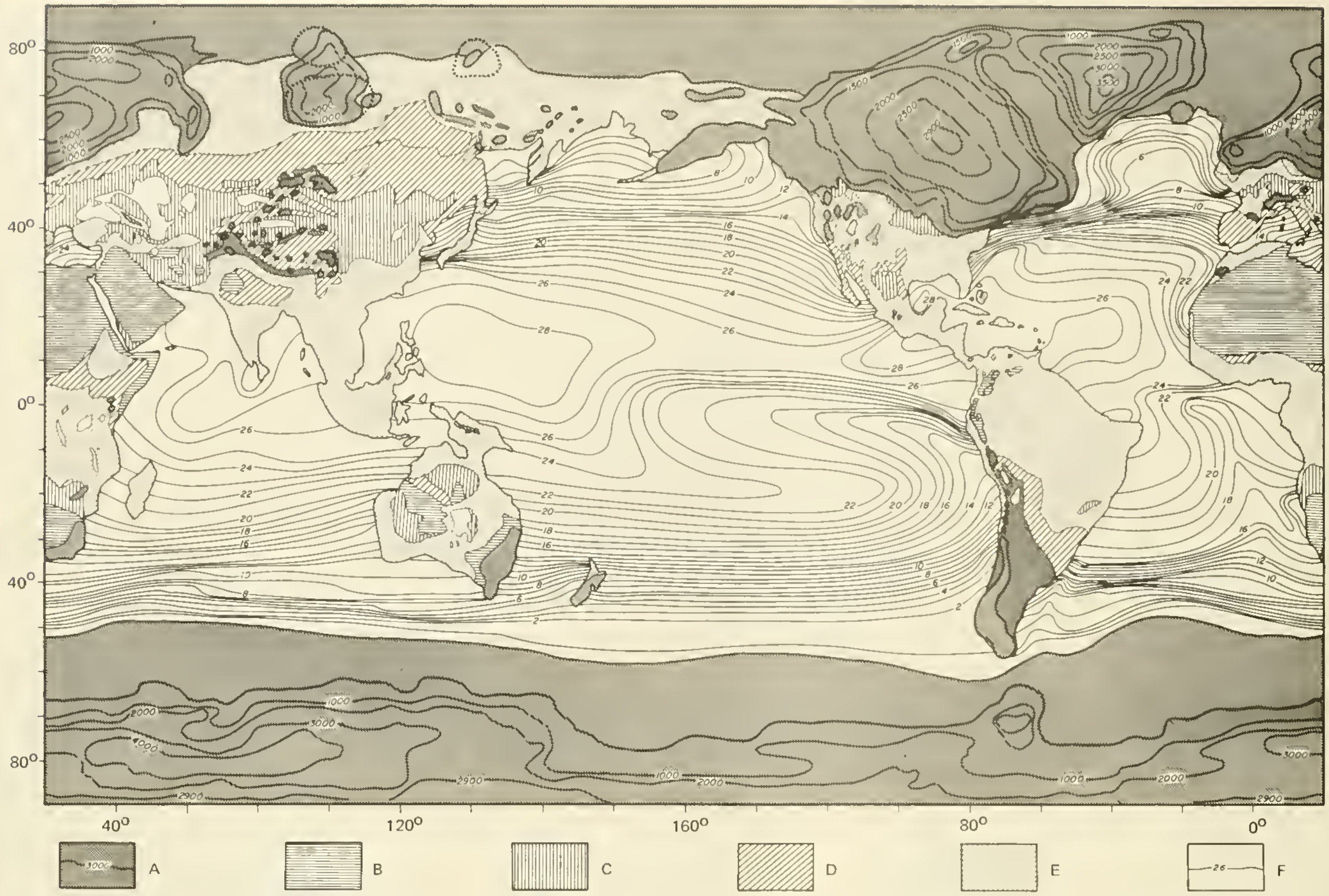

Figure 11.—Sea-surface temperatures, ice extent, ice elevation, and continental albedo for Northern Hemisphere summer (August) 18,000 years ago. See key on facing page.

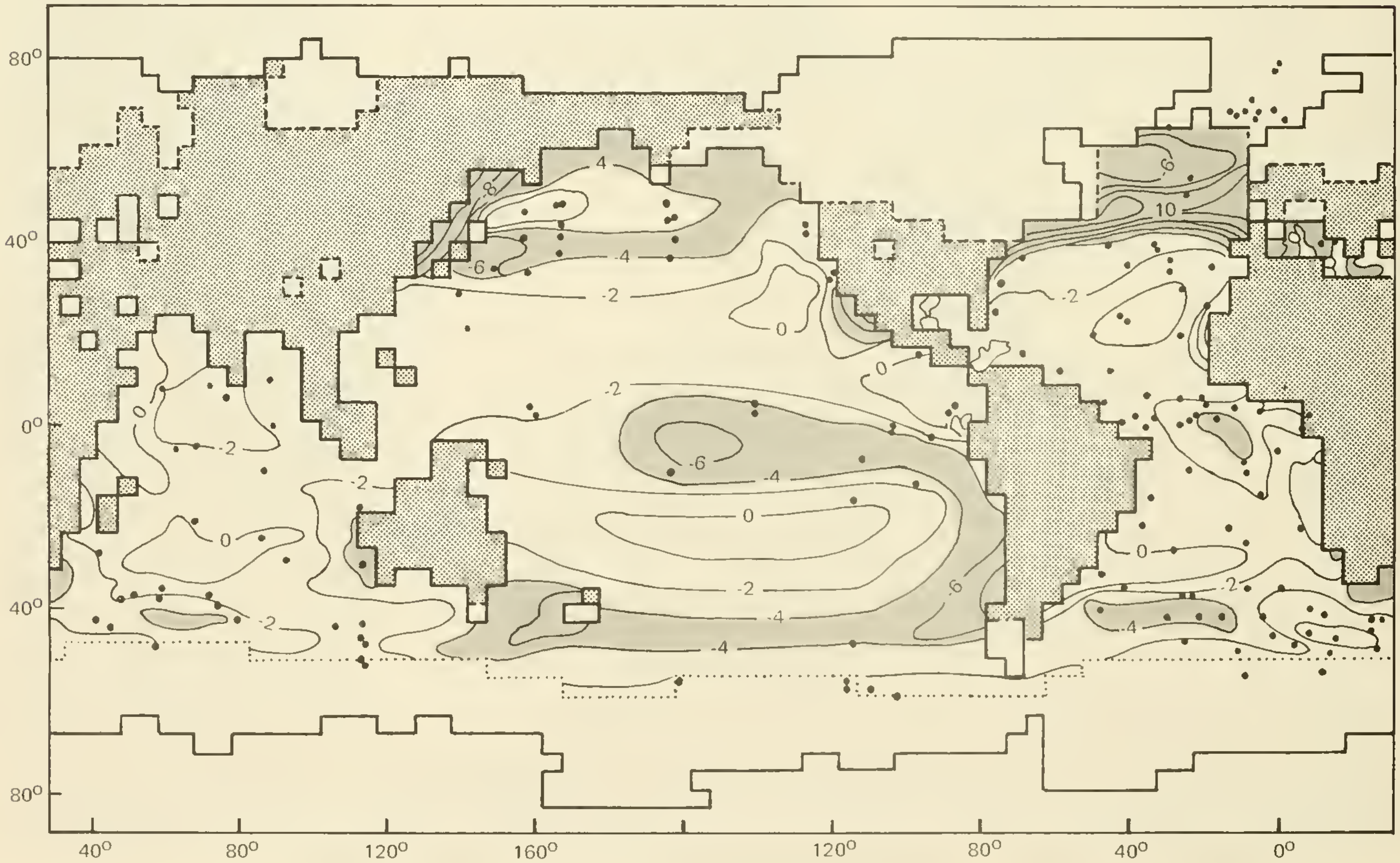

Figure 12.—Difference between August sea-surface temperatures 18,000 years ago and temperatures today. See key on facing page.

Key to figure 11

Contour intervals: for isotherms, 1°C; for ice elevation, 500 m. Continental outlines represent a sea-level lowering of 85 m. In northern Siberia, dotted lines indicate a recently revised estimate of the ice extent; solid lines indicate ice extent actually used in this experiment. Albedo values for nonglaciated land are in map legend. To aid in the visualization of the thermal gradient along the North Atlantic Polar Front, alternate contour lines have been omitted in the western Atlantic.

A. Snow, ice, etc.; albedo over 40%. Isolines showing elevation of the ice sheet above sea level in meters.

B. Sandy deserts, patchy snow, snow covered dense coniferous forests; albedo between 30% and 39%.

C. Loess, steppes, semi-deserts, etc.; albedo between 25% and 29%.

D. Savannas, dry grasslands, etc.; albedo between 20% and 24%.

E. Forested and thickly vegetated land; albedo below 20% (mostly around 15–18%).

F. Ice-free ocean and lakes, with isolines of sea-surface temperature in °C, albedo below 10%.

Key to figure 12

Contour interval is 2°C. Areas where temperature change was greater than 4°C are shown in light stipling. Ice-free land areas are shown in darker stipling. Continental and ice outlines conform to a grid spacing of 4° latitude by 5° longitude. Heavy solid lines indicate continental outlines; dashed lines are ice margins on land; dotted lines indicate sea-ice margins. Large dots mark locations of cores used in reconstructing sea-surface temperatures 18,000 years ago.

Table 9.—CLIMAP Scientists

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CLIMAP Data

The following data are available from EDS' National Geographical and Solar-Terrestrial Data Center.

CLIMAP: Lamont-Doherty Geological Observatorp, J. Hays. Magnetic tape containing 10,072 data entries.

CLIMAP: Lamont-Doherty Geological Observtaory, J. Hays. Updated magnetic tape containing 11,857 data entries.

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Seabed Assessment Program

This program has as its objective the resolution of questions concerning geologic processes along continental margins, mid-ocean ridges, and deep-ocean basins. A better understanding of sea-floor processes will help in locating hydrocarbon and metallic accumulations and other products of economic significance. The subprograms are broadly grouped as Continental Margin Studies, Plate Tectonics and Metallogenesis Studies, and the Manganese Nodule Study.

Projects supported by IDOE are, whenever possible, based on recommendations prepared by participants in scientific workshops sponsored by UNESCO's Intergovernmental Oceanographic Commission (IOC). Scientists from universities, government, and industry, who are investigating the phenomena of interest, are invited to participate in the workshops. Objectives are to determine the present status of knowledge within the related scientific discipline, identify major gaps in what is known, recommend needed research, and develop a strategy for conducting studies. International cooperation and participation is emphasized. Exchange of personnel among countries is encouraged, but each country is expected to bear its own share of the cost.

To carry out the studies, a few large scale projects are supported that require the cooperative efforts of several institutions and several nations. In some cases, one topic is investigated in a single geographic area, such as continental margin work in the South Atlantic, metallogenesis in the FAMOUS area, and manganese nodule studies in the North Central Pacific. Due to the international nature of continental margin studies and metallogenesis, they are investigated in the same broad geographic areas, e.g. Nazca Plate Studies and Studies in East Asia Tectonics and Resources (SEATAR). Consideration has been given to investigating the occurrence of the same phenomena (manganese nodules, subduction zones etc.) in different parts of the world to make comparative studies. This idea has not proven logistically feasible.

Continental Margin Studies

Continental margins can be classified as passive and active types. Passive margins characterize the Atlantic Ocean; active margins, the Pacific Ocean rim. Studies of the eastern and southwest Atlantic continental margins were completed in 1976. Of special concern in these programs were the processes and structural features that controlled the distribution of sediments along the margins of the Atlantic Ocean during its early stages of opening. It was during these early stages that conditions were most favorable for the formation and entrapment of oil.

African Atlantic Margin

This study is divided into three major phases: 1) South Africa to Walvis Ridge; 2) Angola to Sierra Leone; and 3) Senegal to Portugal. The Senegal to Portugal portion of the study was recently completed (fig. 13).

Some general conclusions can now be drawn about the origin and development of the African Atlantic Margin. Studies of both the sea floor and land arch suggest that basement structure resulted from the breakup of Gonwanaland and dispersion of fragments to their present position. Most of the dispersion occurred in the last 150 million years.

African Atlantic Margin Technical and Data Reports

Emery, K. O. 1973: Review of the results from the Eastern Atlantic Continental Margin Program of the International Decade of Ocean Exploration, *Woods Hole Oceanographic Institution Tech. Rep.* Ref. No. WHOI–73–75.

Rona, Peter A. 1972: Exploration methods for continental shelf: geology, geophysics, geochemistry, *NOAA Tech. Rep.* ERL 238–AOML 8, 47 pp.

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Southwest Atlantic Continental Margin

This IDOE project, begun in 1972, complements the work along the East Atlantic to reconstruct the various stages of opening of the South Atlantic Ocean. A team of scientists from Lamont-Doherty Geological Observatory (LDGO) worked from the Scotia Arc at the southern tip of Argentina to the Caribbean off the northeast coast of Brazil. Another group of scientists from Woods Hole Oceanographic Institution (WHOI) investigated the shallow water continental shelf off Brazil. These studies were carried out in cooperation with scientists from Argentina, Brazil, Chile, and the United Kingdom. The investigation of the Scotia Arc involved primarily land work in cooperation with Antarctic investigations by United Kingdom scientists. The participants have sought to determine the structure and early history of the continental margins of both Brazil and Argentina. Researchers prior to this past year have estimated the age and evolution of the Amazon cone and structures on the Brazilian continental shelf, explored sedimentation processes on the eastern margins of Brazil, and conducted extensive geological and geophysical studies on the continental rise and slope off Argentina.

More recent studies have focused on a zone of diapiric structures present within a region of known continental shelf salt and associated evaporities on the margin of eastern Brazil. Lamont-Doherty scientists are attempting to outline the Brazilian diapiric zone and to compare it with a similar zone located on the west African margin in efforts to determine if the west African and Brazilian diapiric zones may have at one time formed a single province prior to the separation of the two continents. Of additional interest in mapping the diapiric zone is the possible association of petroleum deposits with salt diapirs, as is found in other regions like the Gulf of Mexico.

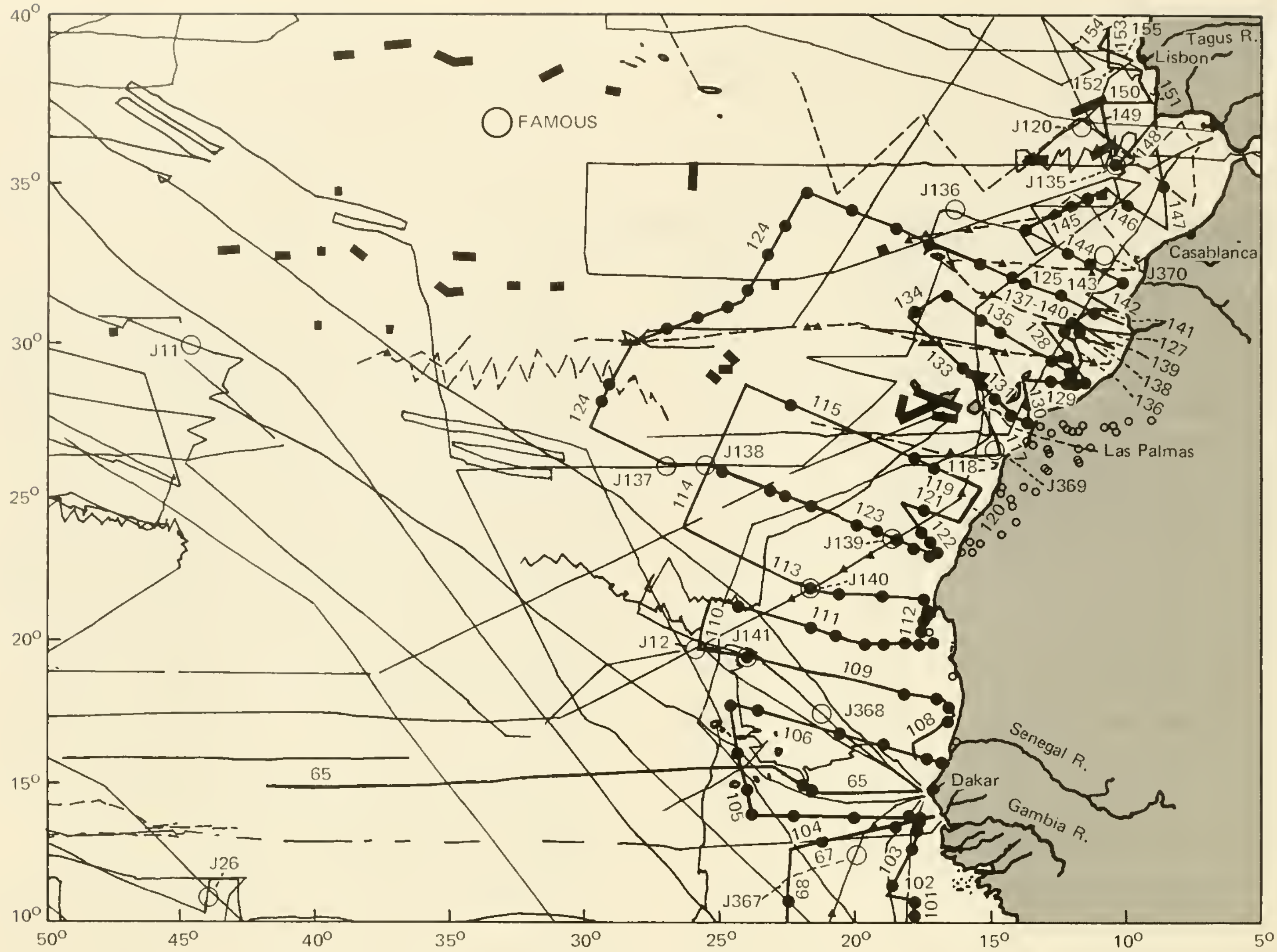

Figure 13.—African Atlantic Margin Project.

Using seismic reflection and refraction data collected during cruises over the past 3 years (fig. 14), Lamont-Doherty scientists determined that a diapiric zone extends along the Brazilian margin for approximately 18° of latitude (fig. 15). At its southern end, the zone is approximately 350 miles wide where it forms the Sao Paulo plateau. A comparison of the Brazilian diapiric zone boundaries with the west African zone, which extends 12° of latitude between Equatorial Guinea and Angola, suggests that in early Cretaceous time the two zones were contiguous and the salt deposits resulted from restricted circulation of marine waters that were enriched in minerals by volcanism during the development of the South Atlantic Ocean.

Investigations of the continental margins of the South Atlantic under the Seabed Assessment and other programs served as excellent site surveys for subsequent Deep-Sea Drilling programs. Three legs were drilled in the South Atlantic. Leg 59 drilled along the coast of Brazil (Sao Paulo and Rio Grande Rise) and the Argentina basin. Leg 60 drilled off southwest Africa (Walvis Ridge and Angola Basin). Leg 61 drilled a series of sites off northwest Africa. Much of the geophysical data is now being correlated with the drilling data. Perhaps the most significant discovery was the widespread occurrence of black shale in the lower part of the geological section, evidence that the nascent Atlantic was cut off from circulation with the open ocean. The Walvis Ridge and Rio Grande Rise appear to have formed a continuous barrier that separated the Cape-Argentine Basin from the Angola-Brazil Basin and produced wide-spread stagnant water conditions (fig. 16). These basins, separated by the ridges, were in effect suffocated by lack of oxygen for a period of 20 million years. Similar environments exist today in the Black Sea where black oil shale forms on the ocean bottom. Such conditions appear to have produced vast deposits of black oil shale in the early Atlantic basins. Geologic processes, however, failed to provide the heat necessary to reduce the oil shale to usable oil.

Studies from the sea floor and land area of South Africa suggest that basement structures are the result of the breakup of Gonwanaland and the dispersion of the fragments to their present position. Most of this dispersion has taken place since the mid-Jurassic. Block faulting and volcanism along the fracture zones that delineate the flow lines of the drifting continents produced the Walvis Ridge, Cape Rise, and Agulhas Plateau. Igneous activity during the early phase of opening of the South Atlantic may have led to emplacement of ridges parallel to the coastline. These served as dams behind which thick deposits of sediments accumulated. These sediments, which form the continental margins, had their sources in the major west-flowing rivers that drained the interior of Africa: the Orange River in

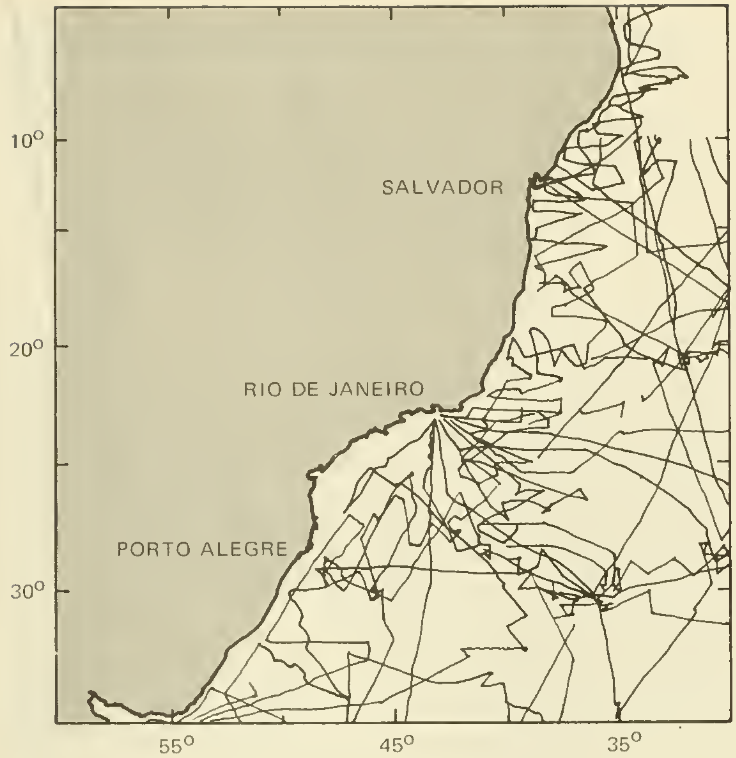

Figure 14.—Lamont-Doherty geophysical cruises on eastern Brazil margin to May 1974. Most coverage within 200 miles of the coast was within last 3 years under IDOE Program.

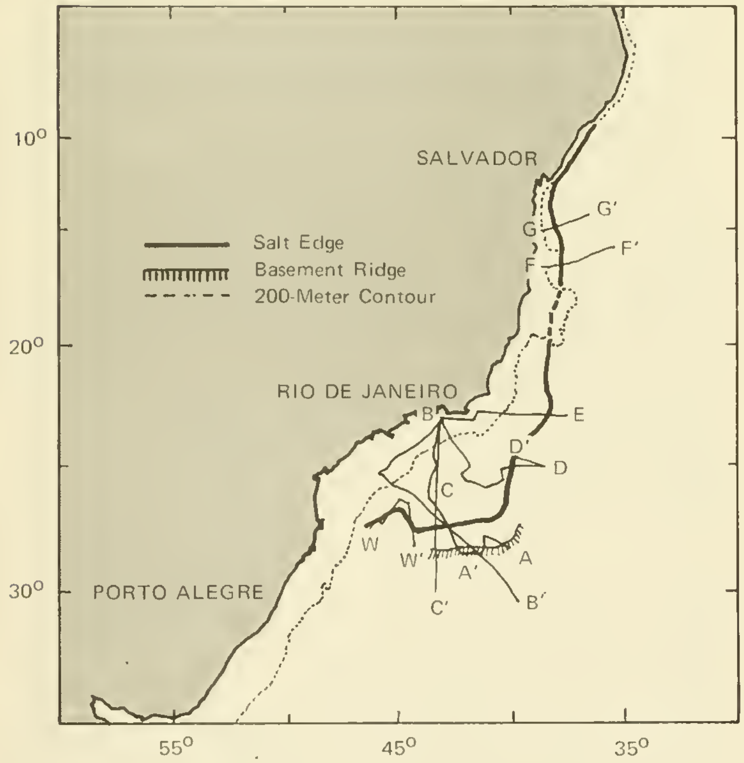

Figure 15.—Boundary of Brazilian diapiric zone and salt deposits. Basement ridge is southeast edge of Sao Paulo plateau.

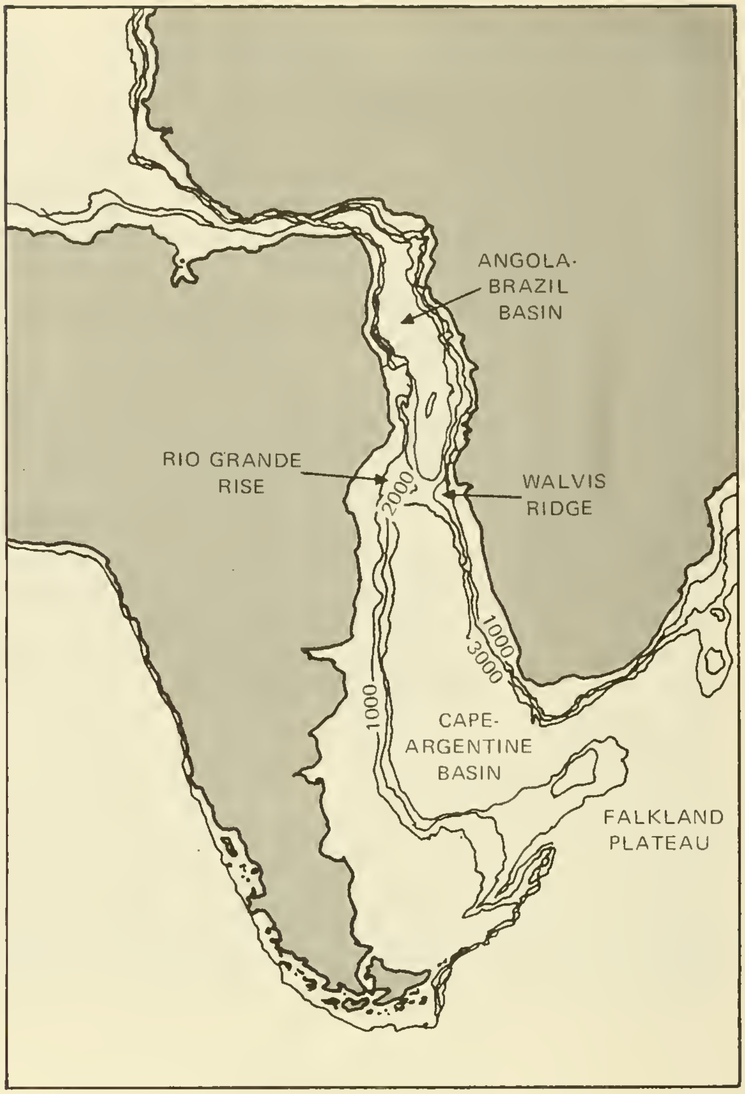

Figure 16.—Paleogeographic features of South Atlantic sea floor—Cape-Argentine Basin, Walvis Ridge/Rio Grande Rise, and Angola-Brazil Basin.

the southwest and the Niger-Benue at the bight. Off the northern bulge, where fluvial influx was lacking, the sedimentary blanket is dominantly calcareous. Later stages of deposition are represented by evaporites. Seismic reflection profiles indicate that the Mesozoic-Cenozoic sediment blanket is thickest beneath the outer continental shelf and upper slope. In various areas increased sediment thicknesses have been observed and in some instances these have been intruded by salt structures of possible Triassic to Jurassic age. However, salt diapirs appear to be restricted to coastal basins and their extensions on the inner shelf.

The major changes in the continental margins appear to be related to sea level variations, orogenies in the Tertiary caused by the convergence of the African and Iberian plates, and changes in deep bottom-water circulation. Some coastal deformation may have been caused by salt tectonics rather than Tertiary orogenies.

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Use of Multichannel Seismic Systems

To acoustically penetrate the thick sedimentary sections along the continental margins and record the stratigraphic changes, multichannel seismic systems must be employed. Such systems have long been used by the oil industry, but the enormous expense of acquisition, operation of the system, and data processing has limited their application by oceanographic research institutions.

The office of IDOE supported development of a 6-channel seismic system at WHOI. The University of Texas (Galveston) received as a gift a 24-channel system and an office data-processing system. IDOE provided support to both institutions to test these systems at sea.

WHOI tested their system off Georges Bank in an area where oil companies made survey results (obtained with 24-channel systems) available as a guide and comparison. This multichannel seismic system was used in the Georges Bank region to determine the seaward extension of Triassic structures in the Gulf of Maine, the westward extension of diapiric structures on the Scotian shelf, and the relation between the structural ridge on the seaward edge of Georges Bank and the diapiric ridge off Browns Bank.

Previous seismic studies off eastern North America, to interpret the structure of the basement underlying the continental margin, were restricted to the Gulf of Maine, where the sediment blanket is thin enough to be penetrated by a single-channel seismic system. However, the basement structures seaward of the Gulf of Maine are masked by Jurassic-Cenozoic deposits as great as 10 km in thicknessss, too massive to be acoustically transparent to a single-channel seismic system.

By using a six-channel system, investigators are determining whether basement structures of the outer continental shelf resulted from tectonic episodes of faulting and basaltic intrusion during separation of the North American and African continents or from vertical migration of sediments. Seismic survey lines will be extended to Browns Bank on the Scotian Shelf to correlate stratigraphic data from a previously drilled deep hole. Data obtained from this investigation and that obtained earlier in the Gulf of Maine will be used to develop a tectonic model of the North American margin. The data will also be used to compile accurate paleographic maps of the Atlantic region prior to formation of the present Atlantic Ocean.

The University of Texas (Galveston) tested its 24-channel seismic system in the western Gulf of Mexico as part of an investigation of the deep structure of the Gulf. The collected

Multichannel seismic system tested by WHOI off Georges Bank

data extends from the abyssal plains of the Sigsbee Deep and along thesedimentary section under the Mexican Ridges.

Plate Tectonics and Metallogenesis Studies

There is increasing evidence that the processes creating new sea floor along the spreading centers and its consumption in the deep ocean trenches are uniquely related to formation of certain types of mineral deposits. Scientists studying the Mid-Atlantic Ridge, the Nazca Plate, and the Galapagos Rift Zone are examining the sequence of rock units present and the role of sea-floor hydrothermal circulation in the formation of metalliferous sediment deposits. The Nazca Plate Study and East Asia Study allow scientists to relate the processes of subduction to mineral deposits in the overlying land masses. and metallogenesis in the overlying land masses.

East and Southeast Asia

A workshop on metallogenesis and tectonic patterns in east and southeast Asia was convened September 1973 in Bangkok, Thailand, under the cosponsorship of the Committee for Coordination of Joint Processing for Mineral Resources in Asia Offshore Areas, the UNESCO Intergovernmental Oceanographic Commission, and the NSF Office for IDOE. The purpose of this workshop was to consider the tectonic development of eastern Asia and its relation to metalliferous ore and hydrocarbon genesis.

Early in the planning phase it was recognized that an adequate synthesis of marine geological and geophysical data for the region did not exist. To gain a thorough understanding of the known tectonic patterns, particularly of the marine areas, and to make efficient application of existing data, it was strongly recommended that efforts be made to compile existing information for the east and southeast Asian areas. This summary will lead to the production of an atlas of marine geological and geophysical data for the seas of the east Asia region. Scientists at Lamont-Doherty Geological Observatory, Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, and Cornell University are involved in the compilation program.

Based on this synopsis of existing data, field programs have been initiated in the Philippine, Banda, and Sunda Arc regions (fig. 17). Scientists from Lamont, Scripps, UCLA, and the Colorado School of Mines are working with Philippine counterparts to obtain better information about the processes that control metal distribution on the island of Luzon. This work will be closely coordinated with marine studies of the Philippine Sea in an attempt to relate both subduction and the tectonic history of this area to metal distribution patterns.

Marine geophysical and geological studies and island mapping programs are being carried out in the Banda and Sunda arc regions. Scientists from Scripps and Woods Hole, and also Indonesia will be carrying out a joint study of the structure

Figure 17.—Six major transects selected for geophysical and geological studies on metallogenesis, hydrocarbons, and tectonic patterns in east and southeast Asia. (*Geotimes* December 1975).

and tectonics of the Banda Sea region during a two-ship program in the area in late 1976. Researchers at Cornell and Scripps will be cooperating in a study of the deformation along the inner wall of the Java Trench. Scientists doing field work on islands have examined deformed, uplifted trench sediments. Preparation of a Heat Flow Map for the area is under way. In addition to data collected at sea, scientists at Scripps and Indonesia are measuring heat flow from oil wells in Indonesia. In a parallel program, scientists from Japan are making measurements in Thailand both on land, in the Gulf of Thailand and in the Andaman Sea. Successful completion of these cooperative efforts should produce the world's second (after North America) most complete heat flow map.

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Nazca Plate

Studies of the Nazca Plate by scientists of the Hawaii Institute of Geophysics and Oregon State University have concentrated on the structure and tectonics along the Peru-Chile Trench and the formation of metalliferous sediments along the East Pacific Rise. Data obtained by the ASPER (Airgun-Sonobuoy-Precision-Echo-Recorder) technique—which provides greater detail of the crustal structure than that obtained from two-ship refraction surveys—indicate faulting of the oceanic crust during subduction. A major offset in crustal layers 300 km west of the trench axis is interpreted as a low angle thrust fault dipping eastward at an average angle of 6° beneath the sea floor. This may indicate that horizontal compression extends to the base of the oceanic crust.

The coast of western South America is composed of three distinct segments. In the northern (4° to 20°S) and southern (28° to 34°S) segments there is evidence that significant amounts of sediments are accreted to the inner wall of the trench. The central segment (20° to 28°S) appears to be an area of nonaccretion and possibly of erosion. Sediment is subducted along with the oceanic crust.

Analyses of extensive sediment samples from the plate indicate that the metal deposits are derived from four distinct sources: hydrothermal, detrital, hydrogenous, and biogenic. The distribution and relative percentage of each metal in a sample is controlled by: 1) supply from the four basic sources, 2) lateral transport by bottom currents, and 3) diagenesis of unstable metalliferous hydroxide in surface sediments to more stable mineral phases, Fe, Mn, and Cu, which are dominantly of hydrothermal origin across most of the plate. Zn also is of dominantly hydrothermal origin, except on the northern portion of the East Pacific Rise, where Zn of biogenic origin from overlying surface waters is present. Diagenesis converts much of the hydrothermal iron and biogenic silica to an iron-rich clay mineral.

Metalliferous sediments accumulate at high rates on both the East Pacific Rise and in the Bauer Basin. A hydrothermal source located along the Rise is consistent with the transition metal and aluminum accumulation rates. In the Bauer Deep the rate of accumulation suggests that either metal-bearing phases are being transported from the Rise or a second hydrothermal source exists within the Bauer Deep.

A workshop was held in October 1975 to better define the relation of Andean metallogenesis and Nazca Plate tectonics, and to identify critical areas for future research emphasis. Important questions that must be answered are the amount and composition of subducted sediments, the degree of hydration and alteration of the oceanic crust, how segmentation of the oceanic crust relates to ore distribution, and how transition metals behave in silicate melts.

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Mid-Atlantic Ridge

The FAMOUS (French-American Mid-Ocean Undersea Study) project is a major international program to interpret the geological processes occurring along mid-ocean ridges. FAMOUS, which is supported in the United States by the Navy, NOAA, and the National Science Foundation, is designed to examine the Mid-Atlantic Ridge in the vicinity of the Azores. The project began in 1971 with broad regional surveys. These were followed by more localized studies of the Rift Valley along the centerline of the rift. This preliminary work provided the basis for an intensive submersible diving program on the ridge during 1974. Three submersibles made 44 dives to the floor of the rift valley and returned with over 1,000 kg of rock samples.

The floor of the rift valley has proven to be much more complex than could be deduced from data collected from the sea surface. The central part of the floor consists of a series of topographic ridges and depressions running down the axis. It is along the ridges that new sea floor is being created. To either side of this central axial zone, marginal depressions are found that result from normal faulting along tensional fractures. The resulting faults and fissures show horizontal separations ranging from a few centimeters to over 8 meters. The walls of the rift valley are normal faults along which the floor of the valley has been uplifted to the crustal ridges. Measured vertical displacements on the faults ranged from less than 1 meter to over 100 meters. Volcanism appeared to be episodic and restricted to the narrow central zone, but tectonic activity was evident throughout the dive area and apparently is continuous. Petrologic and chemical analyses of recovered basalt show a range of composition similar to that shown for basalts of the Atlantic Ocean as a whole. The most significant variations are in the content of titanium, silica, iron, magnesium, calcium, and potassium. Basalt from the young axial volcanic highs tends to be low in these elements, while samples from the rift valley walls show higher contents of these elements.

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Galapagos Rift Zone

Scientists at Woods Hole Oceanographic Institution, Oregon State University, and Scripps Institution of Oceanography are investigating the hydrothermal circulation along the Galapagos Rift Zone, northeast of the Galapagos Islands. Previous studies discovered anomalous bottom-water temperatures, apparently produced by the discharge of heated water that has circulated through the sea floor. Based on the results of an intensive surface ship survey of the area, a diving program may be proposed for the submersible ALVIN. The goal of the submersible program would be to sample and chemically quantify the hydrothermal fluids discharged from the sea floor. Since mixing occurs rapidly with the overlying seawater, it is difficult to estimate either the chemistry or temperature of the discharging fluids. Direct observation and sampling from a submersible are therefore necessary to evaluate those two important parameters.

Manganese Nodule Study

The IDOE Manganese Nodule Program was conceived during a workship at Lamont-Doherty Geological Observatory in January 1972. A multi-institutional approach was recommended to solve the long-standing questions concerning the origin, distribution, and geochemistry of this unique marine resource. At its inception the Manganese Nodule study involved 22 investigators from 13 institutions. Proposed studies were organized into separate phases.

Phase I involved compiling existing manganese nodule data as a baseline for defining the future field work in the program. A series of technical reports and conference proceedings were published as a result of Phase I activities. These were reported in *IDOE Progress Report* Volume 4, April 1974 to April 1975. A project coordinator's office was also established during this interval.

Phase II of the study began in 1974 and is composed of a series of cruises in an area of the northern equatorial Pacific that contains extensive deposits of nodules enriched in copper and nickel (fig. 18). Recovered samples have been distributed to participating institutions for studies of the physical and chemical structure of nodules, chemistry of sediments and interstitial fluids, composition and structure of biogenic components, rate of nodule growth, and characteristics of environments in which nodules occur. Institutions currently involved in the program are the University of Hawaii, Lamont-Doherty Geological Observatory, Massachusetts Institute of Technology, University of Rhode Island, Scripps Institution of Oceanography, University of Southern California, Washington State University, and the University of Wisconsin.

Perhaps the most significant aspect of the program during the year was the development, deployment, and recovery of an ocean-bottom monitoring package. This package was deployed for a period of 4 months near 11°N, 140°W. It contained a camera, current meter, and nephelometer for measuring suspended sediment concentration in the near-bottom water. A preliminary analysis of the data reveals a noticeable variation in suspended material over relatively short periods. Abundant animal life is indicated in bottom photographs, but detailed analysis of time-lapse photographs is necessary to determine whether the organisms significantly disturb or move the nodules.

A future activity of the program will be in-situ experiments and observations from the bottom-monitoring package at several locations in the Pacific. Nodule rich and nodule poor sections of sea floor will be compared.

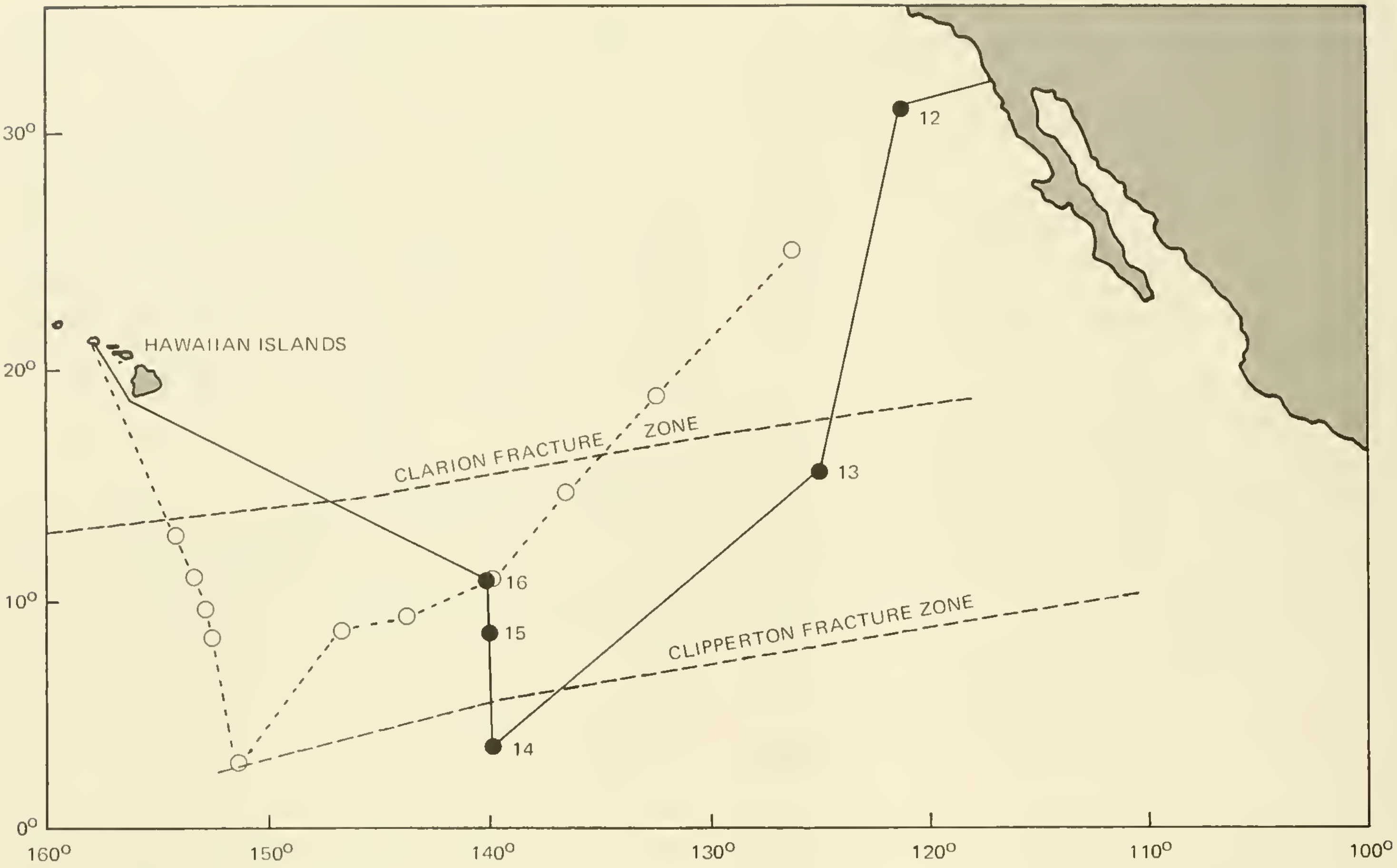

Figure 18.—Location of nodule belt between Clarion and Clipperton fracture zones. Cruise tracks Mn–74–01 (dashed line with open circles) and Mn–74–02 (solid line).

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Seabed Assessment Data Accessioned

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Continental Margin Studies

Eastern Atlantic Continental Margin: Woods Hole Oceanographic Institution, K. O. Emery. ATLANTIS II 75; 24,165 nmi of bathymetry, magnetic, gravity, and seismic data.

Argentina-Brazil Continental Margin: Lamont-Doherty Geological Observatory, G. Bryan. CONRAD 15; 199 dredge sample descriptions; 24,586 nmi of bathymetry, gravity, magnetic and seismic data.

Argentina-Brazil Continental Margin: Lamont-Doherty Geological Observatory, G. Bryan. CONRAD 16; 204 core descriptions; 26,300 nmi of bathymetry, gravity, magnetic, and seismic data.

Argentina-Brazil Continental Margin: Lamont-Doherty Geological Observatory, G. Bryan. VEMA 31; 190 core descriptions; 21,627 nmi of bathymetry, gravity, magnetic, and seismic data.

Western South Atlantic Continental Margin: Woods Hole Oceanographic Institution, J. Milliman. CHAIN 115; 5,575 nmi of bathymetry, gravity, magnetic, and seismic data.

Northwest Atlantic Continental Margin: Woods Hole Oceanographic Institution, K. Prada. ATLANTIS II 91; 3,600 nmi of seismic reflection data.

Plate Tectonics and Metallogenesis Studies

Nazca Plate: Oregon State University, L. Kulm. YAQUINA/YALOC 73; 22,653 nmi of bathymetry, gravity, magnetic, and seismic data.

Nazca Plate: Hawaii Institute of Geophysics, G. Wollard. KANI KEOKI KK 740109; 21,542 nmi of bathymetry, gravity, magnetic and seismic data.

FAMOUS: Woods Hole Oceanographic Institution, W. Dunkle. ALVIN; one reel containing 100 bottom photographs showing individual features found on FAMOUS Fracture Zone.

Manganese Nodule Study

Scripps Institution of Oceanography, J. Greenslate. Magnetic tape of manganese nodule analyses to June 1975; 800 sample locations; 1,700 sample analyses.

JOINT-I research vessel Atlantis II of Woods Hole Oceanographic Institution

Living Resources Program

The goal of this program is to provide scientific knowledge for improved management and use of the ocean's living resources. Emphasis is on interdisciplinary studies of the mechanisms that produce and sustain marine life. The program includes the Coastal Upwelling Ecosystems Analysis (CUEA) and Seagrass Ecosystem Study (SES) projects.

Coastal Upwelling Ecosystems Analysis (CUEA)

The long-term goal of the CUEA program is to understand coastal upwelling ecosystems well enough to predict their response far enough in advance to be useful to mankind. This goal, when achieved, provides the basis for protecting the long-term productivity of fisheries in these ecosystems. There are 20 multidisciplinary projects (table 10). To achieve its goal, CUEA has four objectives:

1. To describe and understand the mesoscale distributions that define coastal upwelling ecosystems in space and time including such variables as radiation, winds, currents, density, nutrients, phytoplankton, zooplankton, nekton, and benthos, and analyses of the spectral characteristics of each.

2. To understand the dynamic processes that affect the total behavior of these ecosystems, and to derive quantitative values of wind-induced upper oceanic circulation, mesoscale flow fields, uptake of nutrients by phytoplankton, and other processes that can limit grazing, predation, excretion, respiration, and remineralization.

3. To learn more about the physical, chemical, and biological interactions that increase the production of coastal upwelling ecosystems, by an order of magnitude, over that of open ocean areas.

4. To develop models that will simulate the Northwest African and Peruvian upwelling ecosystems, and which will provide the basis for predicting the response of these ecosystems to variabilities in scales and rates of processes, or to different fishery management strategies.

Five field programs are complete: MESCAL–I and II (fig. 19), CUE–I and II, and JOINT–I.[1] The sixth, JOINT II, began in March 1976. The methods developed and experience gained in the first four field programs were brought together in

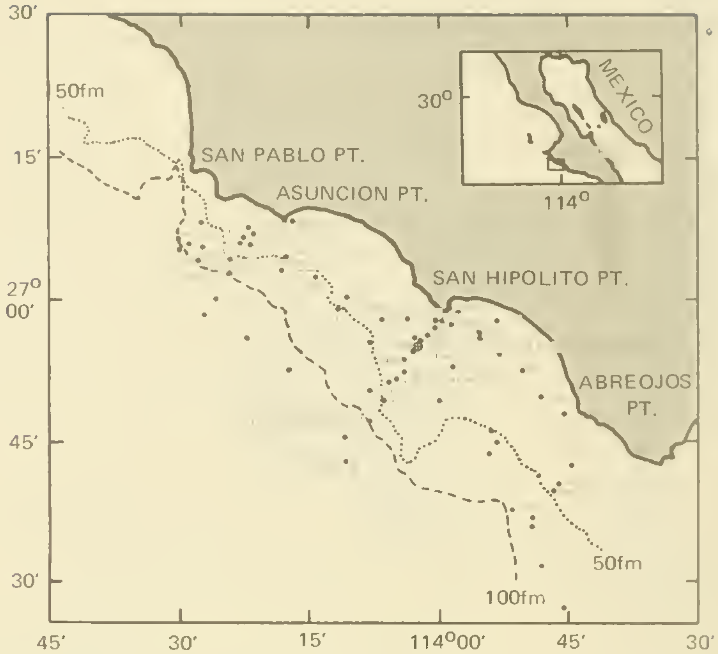


Figure 19.—MESCAL–II station locations. CM is location of current meter.

JOINT–I, the first major CUEA interdisciplinary expedition (figs. 20 and 21). Cooperation with scientists in the CINECA (Cooperative Investigations of the Northern Part of the Eastern Central Atlantic) program made possible an international experiment involving ships, aircraft, equipment, and personnel from 11 countries (fig. 22). The field programs have provided comprehensive and detailed descriptions of the physical, chemical, and biological processes that influence the productivity or potential economic yield of each upwelling ecosystem. The usefulness of the data and findings obtained through the observational phases and theoretical research in the field programs was confirmed at the meeting of the UNESCO Scientific Committee on Oceanic Research (SCOR) Working Group 36 in June 1974, where results from other laboratories and from cruises to the Northwest African and Peruvian upwelling regions were compared.

CUEA will test its newly gained knowledge of upwelling processes in JOINT–II, an intensive collaborative study of the Peruvian upwelling region ecosystem from March 1976 to May 1977. Most JOINT–II investigations will be in an area about 100 by 100 km. centered at 15°S between Pisco and San Juan, Peru (figs. 23 and 24), during three intensive phases: March–

[1] MESCAL I and II were primarily biological studies off the coast of Baja California during March 1972 and March and April 1973. CUE I and II were physical oceanographic studies off the Oregon coast during April through October 1972 and the summer of 1973. JOINT–I was the first integrated biological and physical field study, off the northwest coast of Africa during February through May 1974.

Table 10.—U.S. institutions, investigators, and projects in CUEA program

Organization	Investigator	Project title
University of Alaska	J. J. Goering	Consumption and Regeneration of Silicic Acid in Upwelling Systems
Bigelow Ocean Science Center	R. C. Dugdale	Kinetics of Nutrient Uptake Program Management
	J. MacIsaac	Kinetics of Nutrient Uptake
	T. T. Packard	Enzymatic Determination of Biological Transformation
Brookhaven National Laboratories	J. J. Walsh	Systems Model of Upwelling Ecosystems
	T. E. Whitledge	Nutrient Regeneration and Excretion
University of Delaware	C. N. K. Moores J. C. Van Leer	Physical Dynamics of the Frontal Zone
Duke University	R. T. Barber	Primary Production, Chelation, and Toxicity Program Management
	S. Huntsman	Primary Production, Chelation, and Toxicity
Florida State University	Y. Hsueh	Diagnostic Modelling Studies in JOINT-II
	J. J. O'Brien	Simulation of Time-Dependent Coastal Upwelling Circulation
	D. W. Stuart	Meteorological Suport for the JOINT-II Expedition
Inter-American Tropical Tuna Commission	M. R. Stevenson	Study of Frontal Dynamics and Mesoscale Circulation In Coastal Upwelling Zones by Lagrangian Measurements
Oregon State University	J. S. Allen	Theoretical Studies and the Dynamical Interpretation of Flow Field Observations
	A. Huyer	Mesoscale Hydrography During JOINT-II
	R. L. Smith	Mesoscale Circulation in Coastal Upwelling Systems Program Management
	R. D. Pillsbury	Mesoscale Circulation in Coastal Upwelling Systems
University of Rhode Island	T. J. Smayda	Phytoplankton Species, Succession, and Sinking
San Francisco State College	J. C. Kelley	Nutrient and Phytoplankton Fields; Interactive Real-Time Information System (IRIS); Mesoscale Hydrography During JOINT-II.
University of Washington	D. Halpern	Near-Surface Circulation Studies in A Coastal Upwelling Environment
	L. A. Codispoti	Mesoscale Hydrography During JOINT-II
	O. A. Mathisen R. E. Thorne	Acoustic Assessment of Nekton
Woods Hole Oceanographic Institution	G. T. Rowe K. L. Smith, Jr.	Carbon, Nitrogen ,and Phosphorus Cycles on the Sea Floor of an Upwelling Region

May 1976 (MAM 76), July–November 1976 (JASON 76), and March–May 1977 (MAM 77). Observations will be made from seven U.S. research vessels, Peruvian research vessels, aircraft, moored current meters, coastal meteorological stations, and satellites. The conceptual framework includes four areas of investigation: 1) physical mesoscale studies; 2) frontal studies; 3) biological mesoscale studies of anchoveta and the upwelling ecosystem; and 4) biological mesoscale studies of the circulation and phytoplankton processes.

At the beginning of the CUEA program in 1972, the Peruvian upwelling region was selected as the site for JOINT–II. This selection now appears appropriate for the following reasons:

1. Concepts have been developed concerning processes that enhance the biological productivity off Peru as opposed to the other major upwelling regions of the world. These can now be tested.
2. The Peruvian research institutions—Instituto del Mar del Peru (IMARPE), National Meteorological and Hydrological Service (SENAMHI), Naval Hydrographic and Navigational Directorate (DHNM), Peruvian Geophysical Institution (IGP)—have initiated a program titled "A Study of the Coastal Upwelling System Off Peru." The Peruvian program includes the entire upwelling region along the Peru coast and detailed studies in four important anchoveta fishery regions. These studies will complement the intensive mesoscale studies of CUEA in JOINT–II.

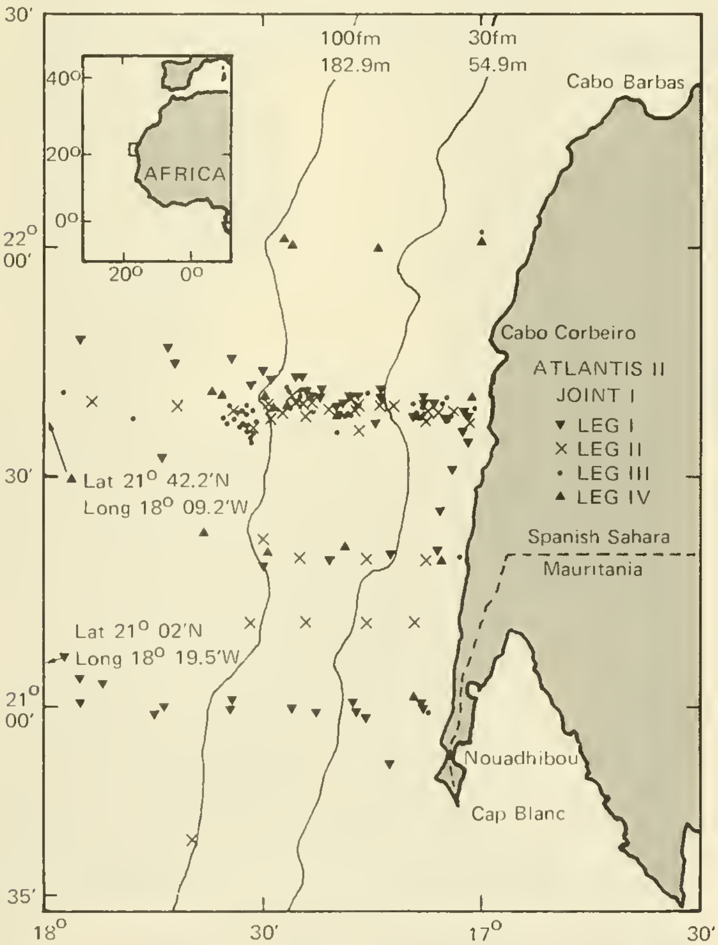


Figure 20.—JOINT–I area and station locations for RV ATLANTIS II cruise 82.

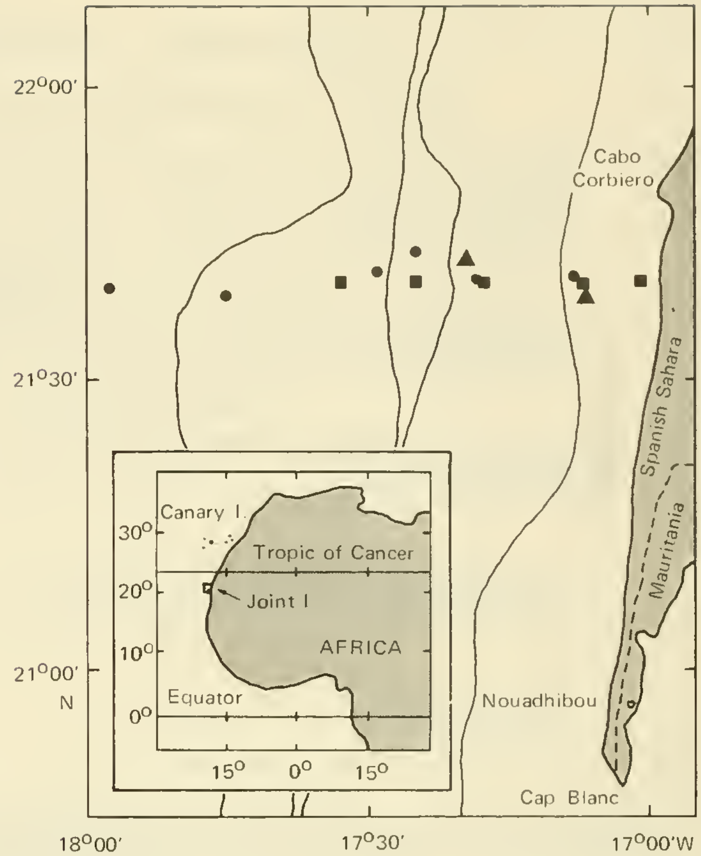


Figure 21.—JOINT–I area showing locations of current meter arrays (circles), meteorological towers (triangles), and productivity and hydrography stations (squares) on latitude 21°40′ line.

3. Instituto del Mar del Peru (IMARPE) will participate in the scientific program of JOINT–II through collaboration of IMPARPE scientists with various CUEA components; by contributing one complete scientific component (Component 19. Zooplankton Fields); and by contributing the use of IMARPE space, facilities, and services for the JOINT–II investigation. This collaboration will make it possible to compare the complex IMARPE fish stock models with CUEA ecosystem models. IMARPE and the Food and Agriculture Organization of the United Nations have developed an assessment and prediction system using five independent determinations of abundance and catch. This program provides monthly predictions of anchoveta stocks. The opportunity exists to apply both IMARPE and CUEA capabilities into a tool for understanding and managing the protein resources of upwelling regions. In June 1975, a formal agreement was reached between CUEA and IMARPE on the areas of participation and collaboration.
4. The Latin American Countries along the Pacific Coast have initiated a study entitled "Estudio Regional del Fenomeno El Niño" (ERFEN). This program will monitor the oceanic and atmospheric environment from about 10 N to 35 S and extending west 500 km from South America. It will document the large-scale climatic and oceanographic features within the JOINT–II study area. JOINT–II results will increase our understanding of the El Niño phenomenon by identifying mesoscale processes that are driven by the large-scale disturbance and which cause the productivity of the region to collapse.

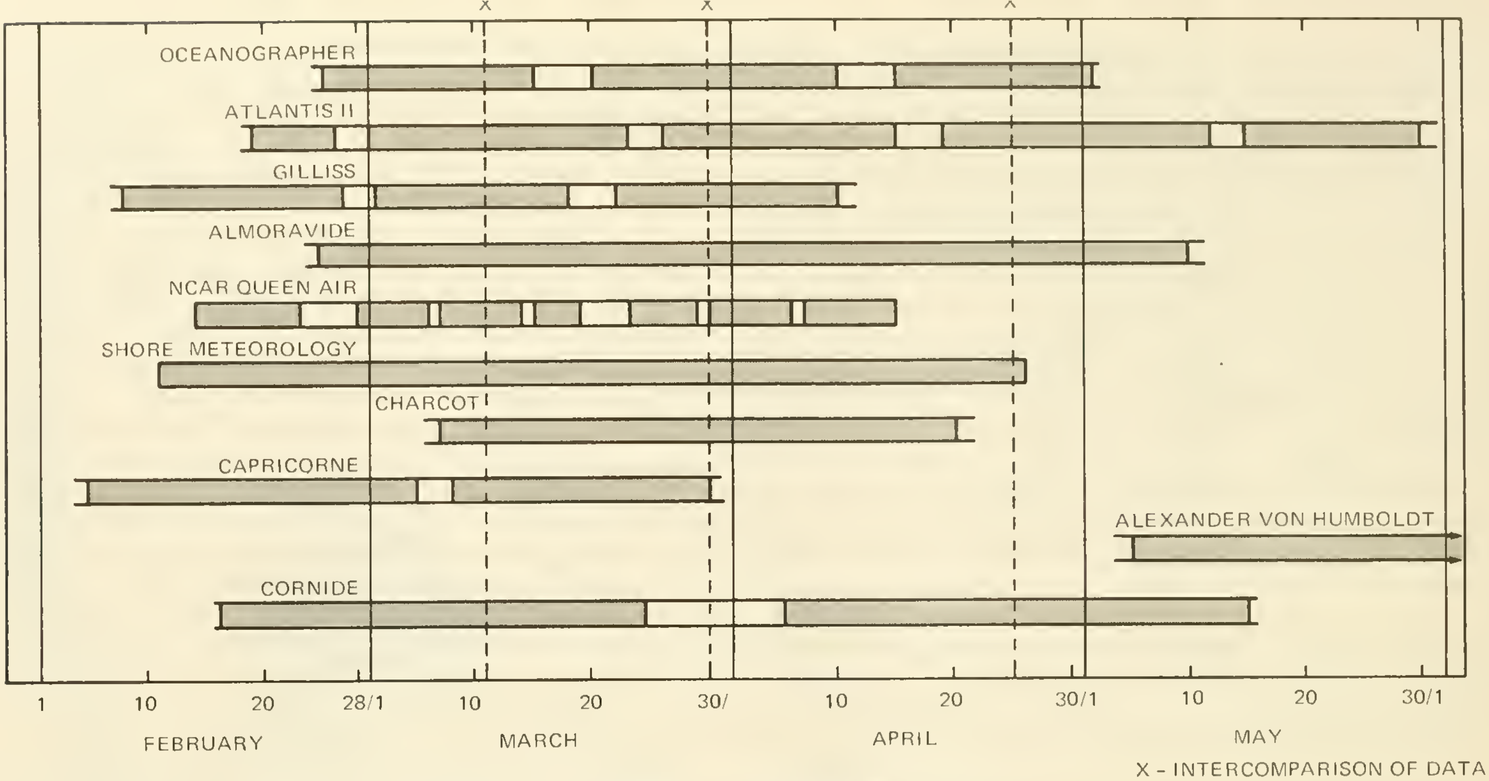


Figure 22.—JOINT-I and CINECA operations off northwest Africa during spring 1974.

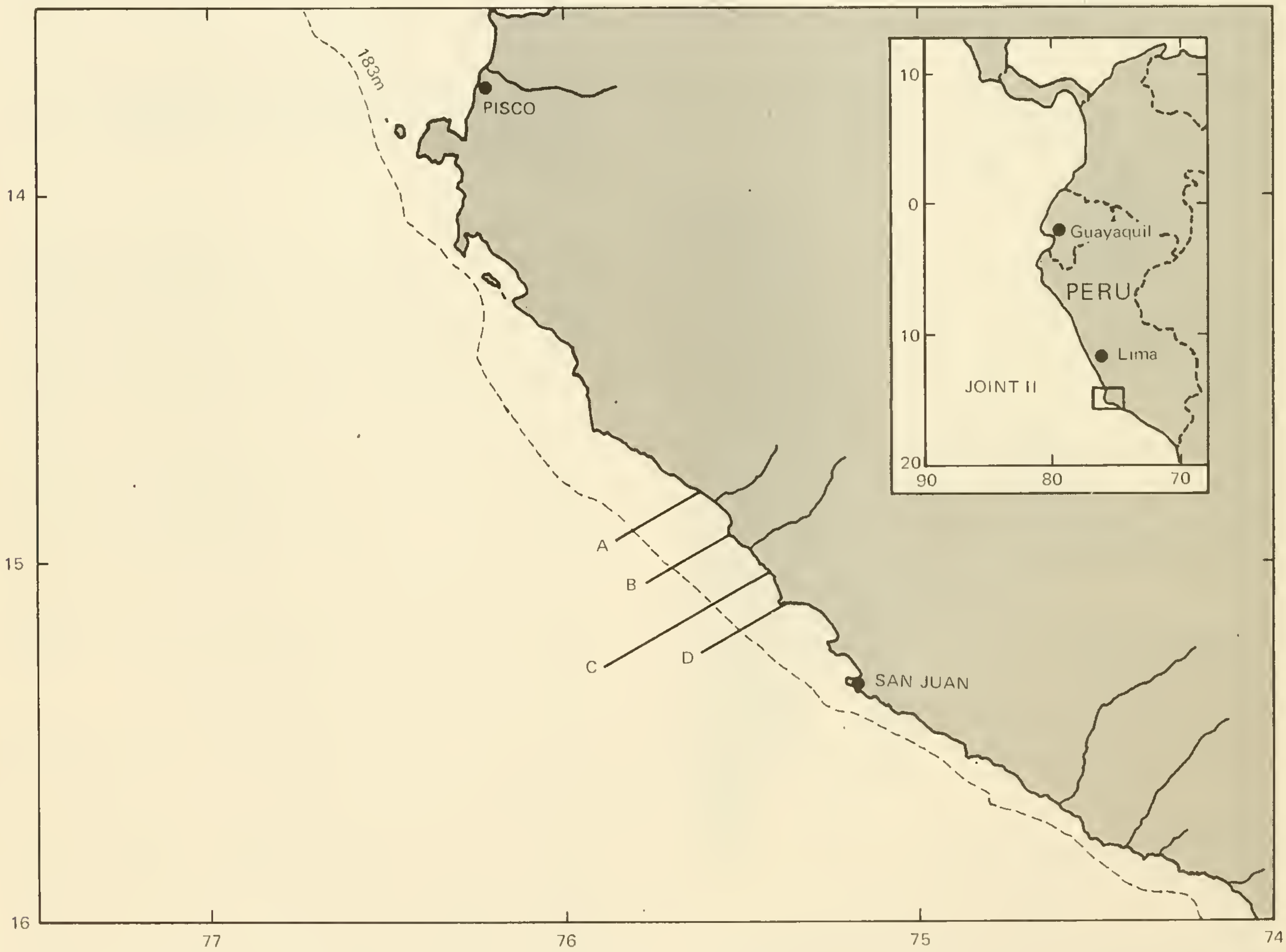


Figure 23.—JOINT-II area and hydrography lines A–D, which form the JOINT-II research grid.

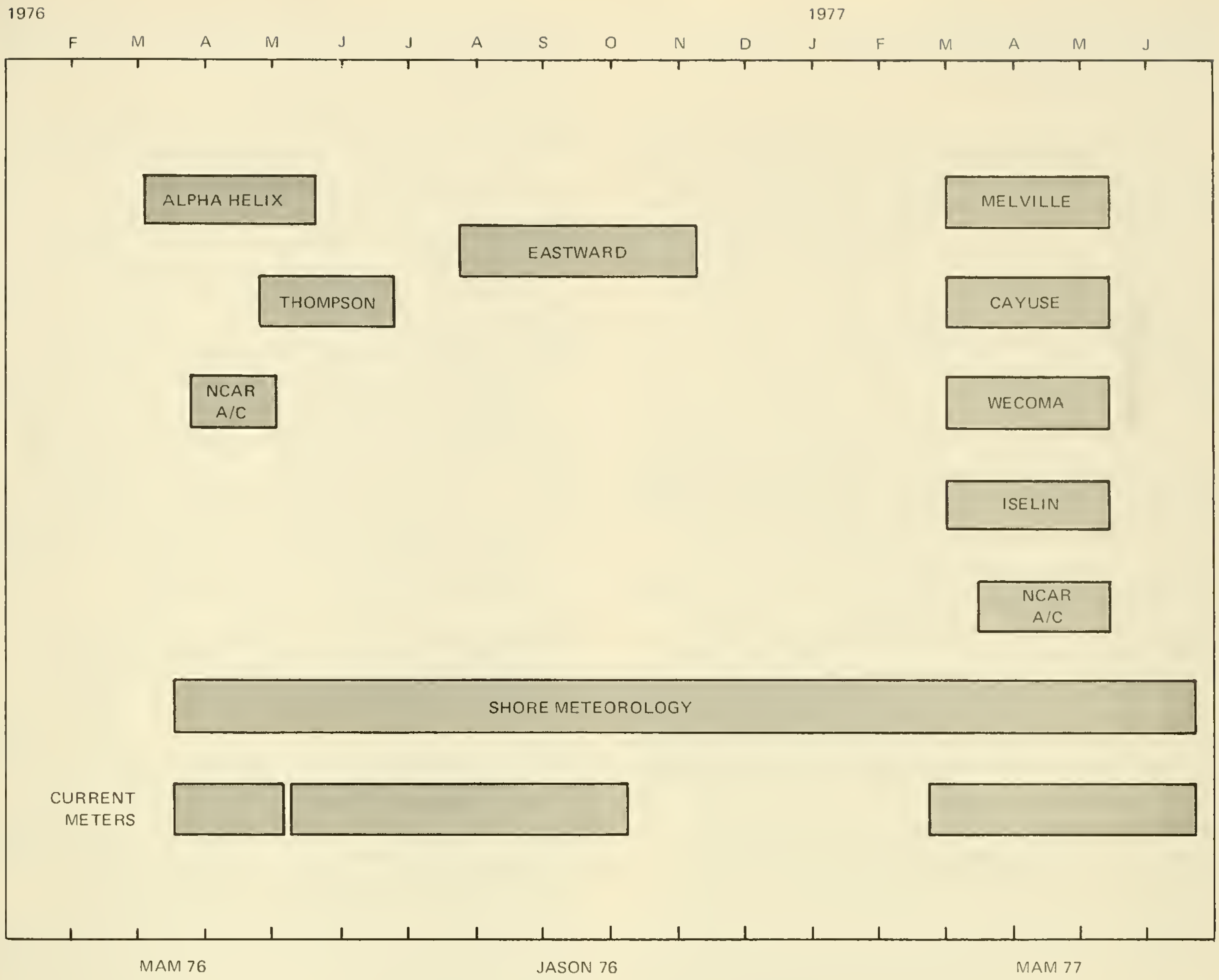
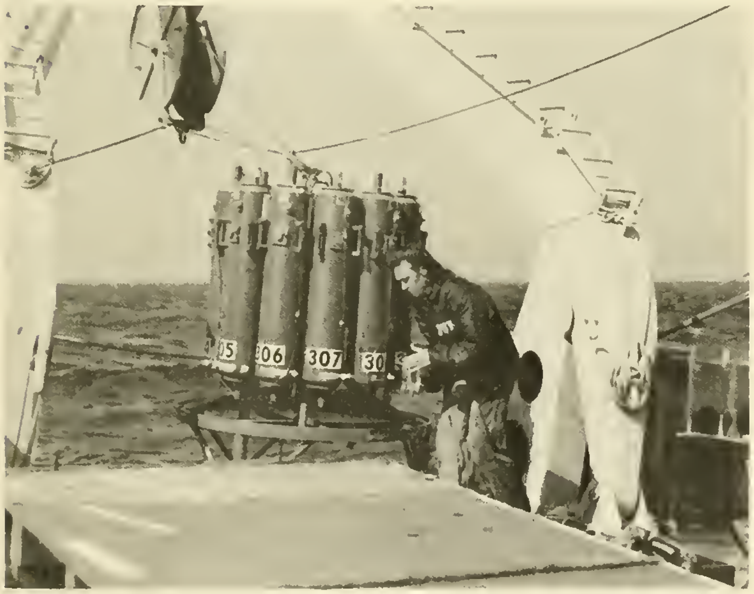


Figure 24.—JOINT–II schedule for intensive phases of the investigation—MAM 76, JASON 76, and MAM 77.



Rosette sampler on board Alpha-Helix during JOINT II MAM 76

CUEA Data

Summaries of CUEA data submitted to EDS' National Oceanographic Data Center follow.

NODC Accession No.: 75–00614
Investigator: D. Halpern, NOAA, PMEL
Project: CUEA (CUE–I)
Grant No.: AG–299

Depth, current, and temperature observations: 556 sets for 10 current meters; July–August 1972; time-series data on magnetic tape.

NODC Accession No.: 76–0564
Investigator: D. Halpern, NOAA, PMEL
Project: CUEA (CUE–II)
Grant No.: AG–299

Depth, temperature, and current observations: 23 files for 18 current meters; July–August 1973; time-series data on magnetic tape.

NODC Accession No.: 76–0744
Investigator: Various CUEA participants.
Project: CUEA (JOINT–I)
Grant No.: Various

Oceanographic station data from the RV Atlantis II cruise 82, 8 March–25 April 1974, 175 serial stations—depth, temperature, salinity, oxygen, apparent oxygen utlization, percent oxygen saturation, chlorophyll, phosphate, silicate, nitrate, nitrite, ETS, C–14, urea, dissolved organic nitrogen, T-particles, particle area and volume, transparency, and ammonia—magnetic tape.

NODC Accession No.: 76–0854
Investigator: Various CUEA participants.
Project: CUEA (MESCAL–II)
Grant No.: Various

Oceanographic station data from the RV T. G. Thompson cruise 78, 24 March–6 May 1973, 108 serial stations—depth, temperature, salinity, oxygen, apparent oxygen utilization, percent oxygen saturation, chlorophyll, phosphate, silicate, nitrate, nitrite, ammonia, and ETS—magnetic tape.

Accession No.: 76–1145
Organization: University of Washington
Investigator: Various CUEA participants.
Grant No.: Various

Contains 73 hydrographic stations from RV T. G. Thompson cruise 81, 11 to 21 July 1973—depth, temperature, salinity, oxygen, apparent oxygen utilization, percent oxygen saturation, phosphate, silicate, nitrate, nitrite, and ammonia—magnetic tape.

NODC Accession No.: 76–1154
Investigator: C. N. K. Mooers, and T. B. Curtin, University of Miami
Project: CUEA (CUE–II)
Grant No.: GX–31264

Profiling current meter data—depth, temperature, salinity, current direction, speed, E–W and N–S component—for RV Yaquina cruise Y7307–B, 16–18 July 1973, 67 profiles; RV Yaquina cruise Y7307–D, 29 July–6 August 1973, 64 profiles; and RV Yaquina cruise &7308–A, 16–20 August 1973, 72 profiles.

STD data—depth, temperature, and salinity—for RV Yaquina cruise Y7307–B, 15–18 July 1973, 69 stations; RV Yaquina cruise Y308–A,16–20 August 1973, 96 stations; and RV Cayuse cruise C7308–E, 18–21 August 1973, 133 stations.

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Transplanting Zostera marina in seagrass garden in Puget Sound. Depth is 15 feet. November 12, 1975

Seagrass Ecosystem Study (SES)

This study was begun in July 1974 to provide information about the benthic marine ecosystem, particularly the dynamic processes by which seagrass ecosystems are maintained, the distribution of these ecosystems, and their contribution to the seas. Initiation of these research activities has resulted from the increased awareness of the importance of nearshore waters in the productivity of the ocean and the vulnerability of these waters to man-induced changes. The increased emphases on nearshore renewable resources led to recognition of how little is known about this important ecosystem.

The Seagrass Ecosystem Study generally addresses three main questions. What are the contributions of seagrass ecosystems to food webs, nutrient and mineral cycling, and coastal stabilization? What processes in seagrass ecosystem are affected by environmental changes or man-induced perturbations? Are there structural patterns in these ecosystems that allow them to persist in changing environments?

The SES program has initiated special field studies and laboratory experiments to answer these questions. Later phases of study will emphasize coordinated, intensive field studies and establishment of a network of national and international field sites for follow-on experiments.

Participants in the SES programs are identified in table 11. International collaboration is maintained through the International Seagrass Committee. Its members are: Tom Fenchel, Denmark; C. den Hartog, The Netherlands; Akihiko Hattori, Japan; C. Peter McRoy, U.S.; Patrick L. Parker, U.S.; and J. M. Peres, France.

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Table 11.—U.S. organizations, investigators, and projects in SES program

Organization	Investigator	Project title
University of Alaska	C. P. McRoy	Process Succession of Seagrass Ecosystems
Fairleigh Dickinson University	J. C. Ogden	Caribbean Seagrass Food Web Study
University of Hawaii	K. W. Bridges	Systematic Ecology
Michigan State University	M. J. Klug R. G. Wetzel	Decomposition of Dissolved and Particulate Organic Detritus in Seagrass Ecosystems
Seattle Pacific College	R. C. Phillips	The Interrelationships of Phenology and Transplanting in the Analysis of Seagrass Stability
University of Texas	P. L. Parker	Stable Carbon Isotope Ratios of Food Webs and Biogeochemical Cycles in Seagrass Ecosystems
	C. McMillan	Environmental Tolerances of Seagrasses
University of Virginia	J. C. Zieman	Caribbean Seagrass Food Web Study

Appendix A—ROSCOP Summaries

In the following ROSCOP (Report of Observations/Samples Collected by Oceanographic Programs) summaries.* all institutions or activities are U.S. participants in IDOE and all projects are part of the Declared National Program (DNP) for Marine Data Exchange. All IDOE-related ROSCOP's received by NOAA's Environmental Data Service from May 1975 to April 1976 are included in this appendix. The reported ROSCOPs bring the IDOE 1970–76 total to 398. Information is presented in the following order:

Line 1: Institution of IDOE grant holder as identified in List of Abbreviations; platform or vessel used to collect data; cruise number and leg, where applicable; cruise period and number of days.

Line 2: NODC record number (reference to this number when requesting ROSCOPs facilitates retrieval of the information); general geographic area.

Line 3: Chief scientist(s); supporting organization(s) indicated in parentheses, as identified in List of Abbreviations; and Marsden Square(s) as shown by charts following Appendix.

Line 4: Grant Number (NSF reference); program or subprogram as indicated in text.

A listing of parameters and the number of stations, samples, or miles of record follows. A dash indicates continuously sampled, not reported, or that a number would not be meaningful.

LIST OF ABBREVIATIONS

Institution of IDOE Grant Holder**

BBS	Bermuda Biological Station
DUKE	Duke University
LDGO	Lamont-Doherty Geological Observatory
MIT	Massachusetts Institute of Technology
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service, NOAA
PMEL	Pacific Marine Environment Laboratory, NOAA
OSU	Oregon State University
SEA	Sailing Education Association
SIO	Scripps Institution of Oceanography
SKIO	Skidaway Institute of Oceanography
TAMU	Texas A&M University
UH	University of Hawaii
URI	University of Rhode Island
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution

Organizations providing support:

AEC	Atomic Energy Commission
EPA	Environmental Protection Agency
NSF IDOE	National Science Foundation—International Decade of Ocean Exploration program
ONR	Office of Naval Research

* See Introduction.

** Certain cooperative data collection efforts were performed on vessels other than those of the grant holder's parent institution, and certain inventory forms were submitted by other institutions.

Pollutant Transfer Program

1. BBS PANULIRUS II, January 1974–December 1975, 48 days
2. NODC Record No. R390963, West Central Atlantic
3. Morris, B. F. (NSF IDOE/ONR) Marsden Squares 115
4. NSF Grant No. GX–32883, pollutant transfer

Physical/Chemical oceanography: STD/CTD vertical profiles 48, oxygen 48
Pollution: particulate organic matter (petroleum fraction) 48.

1. OSU CAYUSE Cruise C7502–A, Leg 1, part 1, February 1975, 4 days
2. NODC Record No. R390394, Northeast Pacific
3. Arnal, R.E. (NSF IDOE) Marsden Squares 120,121
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Geology/Geophysics: grab 16, core-soft bottom 17, physical analysis of sediments 33

1. OSU CAYUSE Cruise C7502–A, Leg 1, part 2, February 1975, 2 days
2. NODC Record No. R390395, Northeast Pacific
3. De Lappe, B. (NSF IDOE) Marsden Squares 121
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Pollution: chlorinated hydrocarbons 6

1. OSU CAYUSE Cruise C7502–A, Leg 1, part 3, February 1975, 3 days
2. NODC Record No. R390397, Northeast Pacific
3. Broenkow, W.W. (NSF IDOE) Marsden Squares 121
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Physical/Chemical oceanography: discrete surface temperature 30, STD/CTD vertical profiles 4, transparency 30.
Pollution: chlorinated hydrocarbons 6

1. OSU CAYUSE Cruise C7502–A, Leg 1, part 4, February 1975, 3 days
2. NODC Record No. R390398, Northeast Pacific
3. Martin, J.H. (NSF IDOE) Marsden Squares 121
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Physical/Chemical oceanography: transparency 12
Pollution: heavy metals 11, chlorinated hydrocarbons 6

1. OSU CAYUSE Cruise C7502–A, Leg 1, part 5, February 1975, 2 days
2. NODC Record No. R390399, Northeast Pacific
3. Martin, J.H. (NSF IDOE) Marsden Squares 121
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Physical/Chemical oceanography: transparency 18
Pollution: heavy metals 6, chlorinated hydrocarbons 6

1. OSU CAYUSE Cruise C7502–A, Leg 2, March 1975, 12 days
2. NODC Record No. R390366, Northeast Pacific
3. Broenkow, W. W. (NSF IDOE) Marsden Squares 83–85, 121, 122
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Physical/Chemical oceanography: discrete surface temperature 31, classical oceanographic stations 5, STD/CTD vertical profiles 31, transparency 3
Pollution: heavy metals 30

1. OSU CAYUSE Cruise C7502–A, Leg 3, March 1975, 13 days
2. NODC Record No. R390392, Northeast Pacific
3. Bruland, K. (NSF IDOE) Marsden Squares 46, 48, 83, 84, 120
4. NSF Grant No. IDO 75–01303, pollutant transfer (BAJA II)

Meteorology: systematic standard measurements 24
Physical/Chemical oceanography: discrete surface temperature 24, classical oceanographic stations 1, expendable bathythermograph 1, transparency 25
Pollution: heavy metals 25, chlorinated hydrocarbons 25.

1. URI TRIDENT Cruise TR–165, April 1975, 19 days
2. NODC Record No. R390519, Northeast and Southwest Pacific
3. DUCE, R. A. (NSF IDOE) Marsden Squares 307, 308
4. NSF Grant No. GX–33777 and GX–33615, pollutant transfer

Meteorology: systematic standard measurements
Physical/Chemical oceanography: continuous surface temperature —, trace elements 35, silicates 9, particulate and dissolved alkali metals —, mercury —
Pollution: petroleum residues 12, chlorinated hydrocarbons 15
Biology: particulate organic carbon 45, dissolved organic matter 18, hydrocarbon concentrations 9

1. URI TRIDENT Cruise TR–169, June–July 1975, 20 days
2. NODC Record No. R390784, Northwest Atlantic
3. Swift, E. (NSF IDOE/AEC) Marsden Squares 79, 115, 116, 151, 152
4. NSF Grant No. GX–33777, pollutant transfer

Meteorology: systematic standard measurements —
Physical/Chemical oceanography: classical oceanographic stations 8, expendable bathythermography 62, transparency 6, phosphate 8, nitrate 8, atmospheric sea salt content 7
Biology: phytoplankton 35, commercial benthic molluscs 3, bioluminescent assay 6

1. SEA WESTWARD Cruise W–13 and W–14, January–March 1974, 68 days
2. NODC Record No. R390964, West Central Atlantic and Caribbean
3. Morris, B. F. (NSF IDOE) Marsden Squares 78–81, 42–45
4. NSF Grant No. GX–32883, pollutant transfer

Pollution: pelagic tar lumps 61
Biology: neuston/pleuston 61

1. SEA WESTWARD Cruise W–19, December 1974–January 1975, 49 days
2. NODC Record No. R390965, Mediterranean and East Central Atlantic

3. Morris, B. F. (NSF IDOE) Marsden Squares 109, 142–144, 179, 180
4. NSF Grant No. GX–32883, pollutant transfer

Pollution: pelagic tar lumps 48, dissolved hydrocarbons 48.
Biology: neuston/pleuston 48

1. TAMU GYRE Cruise 75–G–11, September 1975, 6 days
2. NODC Record No. R390905, Gulf of Mexico
3. Trefry, J. H. (NSF IDOE) Marsden Squares 81, 82
4. NSF Grant No. GX–42576, pollutant transfer

Physical/Chemical oceanography: discrete surface temperature 25, discrete surface salinity 25, classical oceanographic stations 4, oxygen 25, phosphate 15, silicate 15, pH 30, chlorinity 15, trace elements 10
Pollution: suspended solids 30, heavy metals 10, low-molecular-weight hydrocarbons 25
Geology/Geophysics: grab 2, core-rock 4, physical analysis of sediments 28, chemical analysis of sediments 28
Biology: particulate organic carbon 15, dissolved organic matter 15

1. TAMU GYRE Cruise 75–G–16, November 1975, 11 days
2. NODC Record No. R390906, Gulf of Mexico
3. Trefry, J. H./Shokes, R. F. (NSF IDOE/ONR) Marsden Squares 81, 82
4. NSF Grant No. GX–42576, pollutant transfer

Physical/Chemical oceanography: discrete surface temperature 30, discrete surface salinity 30, classical oceanographic stations 9, phosphate 60, silicate 60, pH 25, chlorinity 25, trace elements 10.
Pollution: suspended solids 20, heavy metals 25
Geology/Geophysics: dredge 2, core-soft bottom 30, physical analysis of sediments 50, chemical analysis of sediments 150, geochronology 4
Dynamics: drift cards 250
Biology: particulate organic carbon 18, particulate organic nitrogen

1. WHOI ATLANTIS II Cruise 85, Leg 3, September–October 1975, 14 days
2. NODC Record No. R390778, Northwest Atlantic
3. Teal, J. (NSF IDOE) Marsden Squares 79, 115
4. NSF Grant No. OCE 76–04056, pollutant transfer

Pollution: petroleum residues, 6, chlorinated hydrocarbons 6, contaminated organisms 6
Biology: zooplankton 15, hydrocarbon concentrations 9.

Biological Effects Program

1. TAMU GYRE Cruise 75–G–8, June–July 1975, 11 days
2. NODC Record No. R390660, Northwest Atlantic
3. Sackett, W. M. (NSF IDOE) Marsden Squares 81, 82
4. NSF Grant No. IDO 73–09739, biological effects (GUFEX)

Physical/Chemical oceanography: classical oceanographic stations 23, STD/CTD vertical profiles 2, expendable bathythermograph 35, transparency 2, oxygen 143, phosphate 46, nitrate 46, silicate 46, pH 40, trace elements 32, radioactivity 9, dissolved gases 158.
Geology/Geophysics: core-soft bottom 13, underway bathymetry-wide beam 600 mi
Biology: primary productivity 162, phytoplankton pigment 416, particulate organic carbon 46, dissolved organic matter 46, phytoplankton 42

Midocean Dynamics Experiment (MODE) and POLYMODE

1. MIT CHAIN Cruise 118, January–February 1975, 13 days
2. NODC Record No. R390597, North Atlantic
3. Seaver, G. (NSF IDOE) Marsden Squares 109–115, 151
4. NSF Grant No. IDO 75–04215, POLYMODE

Physical/Chemical oceanography: expendable bathythermograph 382

1. URI EASTWARD Cruise E–11–75, September–October 1975, 10 days
2. NODC Record No. R390739, Northwest Atlantic
3. Watts, D. R. (NSF IDOE) Marsden Squares 115, 116
4. POLYMODE

Physical/Chemical oceanography: continuous surface temperature –, classical oceanographic stations 1, expendable bathythermograph 48, oxygen 1
Geology/Geophysics: underway bathymetry-wide beam –
Dynamics: inverted echo sounders –

1. URI TRIDENT Cruise 168, May–June 1975, 19 days
2. NODC Record No. R390646, Northwest Atlantic
3. Richardson, P. L. (NSF IDOE/ONR) Marsden Squares 80, 152
4. NSF Grant No. IDO 75–08765/GX–30416, POLYMODE

Physical/Chemical oceanography: STD/CTD vertical profiles 17, expendable bathythermograph 305, oxygen 12, phosphate 20, total–P 20
Pollution: pesticides 27, organophosphorous 20, total organic carbon 20
Geology/Geophysics: underway seismic reflection 20

1. URI/WHOI TRIDENT Cruise TR–174, October–November 1975, 23 days
2. NODC Record No. R390890, Central North Atlantic
3. Ledbetter, M. T. (NSF IDOE/ONR) Marsden Squares 109–115
4. NSF Grant No. IDO 75–04215/IDO 75–22133, POLYMODE and CLIMAP

Physical/Chemical oceanography: discrete surface temperature 384, expendable bathythermograph 384
Geology/Geophysics: cores 55, underway bathymetry-wide beam 3300 mi

1. URI TRIDENT Cruise TR–175, November–December 1975, 21 days
2. NODC Record No. R390908, Northwest Atlantic
3. Richardson, P. L. (NSF IDOE/ONR) Marsden Squares 114–116, 152
4. NSF Grant No. IDO 75–08765, POLYMODE

Physical/Chemical oceanography: CTD/O_2 vertical profiles 11, expendable bathythermograph 438, oxygen 10
Dynamics: free-drifting buoy 1

1. WHOI CHAIN Cruise 116, July–August 1975, 20 days
2. NODC Record No. R390780, Northwest Atlantic
3. Heinmiller, R. H. (NSF IDOE/ONR) Marsden Squares 78, 79, 114, 115, 151 and 152
4. NSF Grant No. GX–29054, MODE/POLYMODE

Physical/Chemical oceanography: continuous surface temperature 2300 mi, continuous surface salinity 2300 mi, STD/CTD vertical profiles 32, expendable bathythermograph 284, carbonate dissolution samples on moorings 34
Geology/Geophysics: magnetic properties of the sea floor 3, underway bathymetry-wide beam 1500 mi
Dynamics: current meters 33 stations, 280 days

1. WHOI KNORR Cruise 39, April 1974, 18 days
2. NODC Record No. R390804, Northwest Atlantic
3. Tupper, G. H. (NSF IDOE/ONR) Marsden Squares 79, 115, 116
4. MODE

Physical/Chemical oceanography: STD/CTD vertical profiles 19, expendable bathythermograph 42, calcium deposition samples 8
Dynamics: current meters 8 stations, 120 days

1. WHOI KNORR Cruise 44, December 1974, 19 days
2. NODC Record No. R390801, Northwest Atlantic
3. Tupper, G. (NSF IDOE/ONR) Marsden Squares 115, 116
4. POLYMODE

Physical/Chemical oceanography: STD/CTD vertical profiles 39, expendable bathythermograph 153
Dynamics: current meters 15 stations, 240 days

1. WHOI KNORR Cruise 49, April–May 1975, 29 days
2. NODC Record No. R390495, Northwest Atlantic
3. Schmitz, W. (NSF IDOE/ONR) Marsden Squares 78, 79, 115, 116, and 150
4. NSF Grant No. IDO 75–03962, POLYMODE

Physical/Chemical oceanography: classical oceanographic stations 2, expendable bathythermograph 535, oxygen 17
Geology/Geophysics: underway bathymetry-wide beam 5,000 mi
Dynamics: current meters 9 stations, 270 days

1. WHOI KNORR Cruise 52, October–November 1975, 28 days
2. NODC Record No. R390802, Northwest Atlantic
3. Sanford, T. B. (NSF IDOE/ONR) Marsden Squares 115, 151
4. POLYMODE

Physical/Chemical oceanography: STD/CTD vertical profiles 79, expendable bathythermograph 23, temperature and salinity measurements from free-falling instrument 336
Dynamics: electro-magnetic current velocity profiles 82

North Pacific Experiment (NORPAX)

1. UH MOANA WAVE Cruise El Nino, Leg 1, February–March 1975, 28 days
2. NODC Record No. R390478, Northeast and Southwest Pacific
3. Patzert, W. (NSF IDOE) Marsden Squares 9–11, 47, 83–85, 122, 308, 309, 344, 345
4. NSF Grant No. IDO 75–06468, NORPAX (El Nino Watch)

Meteorology: upper air observations 50, incident radiation –, systematic standard measurements –
Physical/Chemical oceanography: continuous surface tem-

perature –, continuous surface salinity –, discrete surface temperature –, discrete surface salinity –, classical oceanographic stations 26, STD/CTD vertical profiles 55, expendable bathythermograph 300, oxygen 26, phosphate 26, nitrate 26, nitrite 26, silicate 26
Dynamics: current meters 3, electric field current meters 3
Biology: primary production 26, phytoplankton pigment 26, zooplankton 55

1. UH MOANA WAVE Cruise El Niño, Leg 2, March 1975, 15 days
2. NODC Record No. R390479, Northeast and Southwest Pacific
3. Patzert, W. (NSF IDOE) Marsden Squares 8, 9, 308, 343, 344
4. NSF Grant No. IDO 75–06468, NORPAX (El Niño Watch)

Meteorology: upper air observations 24, incident radiation –, systematic standard measurements –
Physical/Chemical oceanography: continuous surface temperature –, continuous surface salinity –, discrete surface temperature –, discrete surface salinity –, classical oceanographic stations 19, STD/CTD vertical profiles 38, expendable bathythermograph 132, oxygen 19, phosphate 19, nitrate 19, nitrite 19, silicate 19
Geology/Geophysics: core-soft bottom 1
Biology: primary production 19, phytoplankton pigments 19, zooplankton 38

1. UH MOANA WAVE Cruise El Niño, Leg 3, April–May 1975, 25 days
2. NODC Record No. R390480, Northeast and Southwest Pacific
3. Stroup, E. (NSF IDOE) Marsden Squares 9, 10, 308, 309, 343–345
4. NSF Grant No. IDO 75–06468, NORPAX (El Niño Watch)

Meteorology: upper air observations –, incident radiation –, systematic standard measurements –
Physical/Chemical oceanography: continuous surface temperature –, continuous surface salinity –, discrete surface temperature –, discrete surface salinity –, classical oceanographic stations 29, STD/CTD vertical profiles 61, expendable bathythermograph 288, oxygen 29, phosphate 29, nitrate 29, nitrite 29, silicate 29
Biology: primary productivity 29, phytoplankton pigments 29, zooplankton 60

1. UH MOANA WAVE Cruise El Niño, Leg 4, May 1975, 13 days
2. NODC Record No. R390566, Northeast and Southwest Pacific
3. Stroup, R. (NSF IDOE) Marsden Squares 8, 9, 308, 343, 344
4. NSF Grant No. IDO 75–06468, NORPAX (El Niño Watch)

Meteorology: upper air observations 22, incident radiation –, systematic standard measurements –
Physical/Chemical oceanography: continuous surface temperature, continuous surface salinity –, discrete surface temperature –, discrete surface salinity –, classical oceanographic stations 18, STD/CTD vertical profiles 36, expendable bathythermograph 133, oxygen 18, phosphate 18, nitrate 18, nitrite 18, silicate 18
Biology: primary production 18, phytoplankton pigment 18, zooplankton 33

International Southern Ocean Studies (ISOS)

1. LDGO CONRAD Cruise CO 18–01, February–March 1975, 39 days
2. NODC Record No. R390473, South Atlantic and South Pacific
3. Gordon, A. (NSF IDOE) Marsden Squares 485, 486
4. NSF Grant No. OCE 74–15062, ISOS

Physical/Chemical oceanography: continuous surface temperature 5,000 mi, discrete surface temperature 182, discrete surface salinity 150, STD/CTD vertical profiles 59, expendable bathythermograph 182, oxygen 59, phosphate 59, silicate 59, trace elements 15, isotopes 5
Geology/Geophysics: underway bathymetry-wide beam 5,000 mi, underway seismic reflection 5,000 mi, underway gravimetry 5,000 mi, underway magnetism 5,000 mi, core-soft bottom 9

1. OSU CAYUSE Cruise C7508–B, August 1975, 2 days
2. NODC Record No. R390687, Northeast Pacific
3. Baker, D. J. (NSF IDOE) Marsden Squares 157
4. SF Grant No. IDO 75–03961, ISOS

Meteorology: occasional standard measurements 1
Dynamics: deployment of 2 pressure gauges

1. SIO MELVILLE Cruise F DRAKE, Leg 1, January–February 1975, 26 days
2. NODC Record No. R390402, Southwest Atlantic, Northeast and Southwest Pacific
3. Nowlin, W./Winterow, S. (NSF IDOE) Marsden Squares 12, 47, 48, 85, 121, 310, 345, 346, 381, 417, 450, 452, 453, 486–488
4. NSF Grant No. IDO 74–14941, ISOS (F Drake)

Geology/Geophysics: underway bathymetry-wide beam –, underway bathymetry-narrow beam –, magnetism –
Physical/Chemical oceanography: expendable bathythermograph 190
Biology: surface tows for freezing nuclei –

1. OSU CAYUSE Cruise C7509–C, September 1975, 1 day
2. NODC Record No. R390743, Northeast Pacific
3. Baker, D. J., Wern, R. (NSF IDOE) Marsden Squares 157
4. NSF Grant No. IDO 75–03961, ISOS

Meteorology: occasional standard measurements 1
Dynamics: tidal observations 2

1. SIO MELVILLE Cruise F DRAKE, Leg 4, May 1975, 8 days
2. NODC Record No. R390634, East Central Pacific
3. Keith, W. (NSF IDOE) Marsden Squares 9, 46, 47
4. NSF Grant No. OFS 74–01830, ISOS

Physical/Chemical oceanography: expendable bathythermograph 10
Geology/Geophysics: underway bathymetry-wide beam –, underway magnetism –

1. TAMU ISLAS ORCADAS Cruise 75–04/F DRAKE, January–March 1975, 53 days
2. NODC Record No. R390400, South Pacific and Southwest Atlantic
3. Park, P. K. (NSF IDOE) Marsden Squares 485–487, 522
4. NSF Grant No. IDO 75–09525, ISOS (F Drake)

Physical/Chemical oceanography: continuous surface temperature 2000 mi, classical oceanographic stations 30, STD/CTD vertical profiles 85, expendable bathythermograph 150, oxygen 30, phosphate 30, nitrate 30, silicate 30
Geology/Geophysics: underway bathymetry-wide beam 2,000 mi

1. TAMU MELVILLE Cruise F DRAKE, Leg II, February–April 1975, 45 days
2. NODC Record No. R390401, Southeast Pacific and Southwest Atlantic
3. Nowlin, W. D./Pillsbury, D. (NSF IDOE) Marsden Squares 485, 486
4. NSF Grant No. IDO 74–14941, ISOS (F Drake)

Meteorology: occasional standard measurements 70, systematic standard measurements 160
Physical/Chemical oceanography: continuous surface temperature 3,700 mi, continuous surface salinity 3,700 mi, discrete surface temperature 226, discrete surface salinity 225, classical oceanographic stations 64, STD/CTD vertical profiles 87, expendable bathythermograph 239, oxygen 64, phosphate 64, nitrate 64, nitrite 64, silicate 64, surface silicate 15
Geology/Geophysics: underway bathymetry-wide beam 5000 mi
Dynamics: current meters 9 stations, 270 days

Climate: Long Range Investigation, Mapping, and Prediction (CLIMAP) Study

1. URI/OSU TRIDENT Cruise TR–173, July–October 1975, 105 days
2. NODC Record No. R390849, Tyrrhenian Sea, Balearic Sea, Alboran Sea, Straits of Gibraltar and Northeast Atlantic
3. Thiede, J. (NSF IDOE) Marsden Squares 109, 143, 179, 144
4. NSF Grant No. IDO 75–22133, CLIMAP

Physical/Chemical oceanography: isotopes –
Geology/Geophysics: cores-rock 1, cores-soft bottom 26, underway bathymetry-wide beam 1500 mi, underway seismic reflection 1500 mi, C–14 studies of pore water 38

Continental Margin Studies

1. WHOI ATLANTIS II Cruise 91, Legs 1 and 2, July–August 1975, 45 days
2. NODC Record No. R390779, Northwest Atlantic
3. Prada, K. E. (NSF IDOE) Marsden Square 151
4. NSF Grant No. GX–41962, Continental Margin

Physical/Chemical oceanography: discrete surface temperature 408, discrete surface salinity 408, water color 154, expendable bathythermograph 50

Geology/Geophysics: reflection/refraction-wide angle (radio buoy) 330, underway bathymetry-wide beam 6217 mi, underway seismic reflection 6,217 mi, underway magnetism 6,217 mi

Plate Tectonics and Metallogenesis Studies

1. OSU MELVILLE Cruise F DRAKE, Leg III, April–May 1975, 38 days
2. NODC Record No. R390651, Southwest Pacific
3. Prince, R. (NSF IDOE) Marsden Squares 379, 415
4. NSF Grant No. GX–28675, Nazca Plate (F Drake)

Physical/Chemical oceanography: expendable bathythermograph 105

Geology/Geophysics: dredge 6, core-soft bottom 8, underway bathymetry-wide beam 6,000 mi, magnetism 6,000 mi

Biology: zooplankton –, nekton 3, invertebrate nekton –

Coastal Upwelling Ecosystems Analysis (CUEA)

1. DUKE EASTWARD Cruise E–5A–75, July 1975, 1 day
2. NODC Record No. R390732, Northwest Atlantic
3. Barber, R. (NSF IDOE) Marsden Square 116
4. NSF Grant No. OCE 75–23722, CUEA

Physical/Chemical oceanography: continuous surface temperature 3, continuous near-bottom temperature 3, expendable bathythermograph 3
Dynamics: current meters 2 stations

1. DUKE EASTWARD Cruise E–5B–75, July 1975, 6 days
2. NODC Record No. R390733, Northwest Atlantic
3. Barber, R. T. (NSF IDOE) Marsden Square 116
4. NSF Grant No. OCE 75–23722, CUEA

Physical/Chemical oceanography: discrete surface temperature –, discrete surface salinity –, discrete near-bottom salinity –, STD/CTD vertical profiles 1, expendable bathythermograph –, phosphates –, nitrates, nitrites –, silicates –
Geology/Geophysics: underway bathymetry-wide beam –, dredge –
Biology: taxonomy, systematics, classification 4, primary productivity –, phytoplankton pigment –, pelagic fishes 4, taggings 4

1. DUKE EASTWARD Cruise E–7–75, August 1975, 4 days
2. NODC Record No. R390735, Northwest Atlantic
3. Barber, R. T., Pillsbury, D. (NSF IDOE) Marsden Square 116
4. NSF Grant No. OCE 75–23722/OCE 76–00132, CUEA

Meteorology: wind speed and direction 20
Physical/Chemical oceanography: continuous surface temperature 21, continuous surface salinity 21, discrete surface temperature 20, discrete surface salinity 20, continuous near-bottom temperature 21, continuous near-bottom salinity 20, discrete near-bottom temperature 20, discrete near-bottom salinity 20, STD/CTD vertical profiles 21, expendable bathythermograph 39, phosphate 20, nitrate 20, nitrite 20, silicate 20
Dynamics: current meters 2
Biology: phytoplankton pigment 20

1. OSU CAYUSE Cruise C7504–C, April 1975, 2 days
2. NODC Record No. R390413, Northeast Pacific
3. Smith, R. L., Pillsbury, R. D. (NSF IDOE) Marsden Squares 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Dynamics: current meters 3 stations, 90 days

1. OSU CAYUSE Cruise C7505–D, May 1975, 3 days
2. NODC Record No. R390496, Northeast Pacific
3. Smith, R. L. (NSF IDOE) Marsden Square 157
4. NSF Grant No. DES 74–22290, CUEA

Meteorology: occasional standard measurements 1
Dynamics: current meters 1 station, 90 days

1. OSU CAYUSE Cruise C7509–D, September 1975, 2 days
2. NODC Record No. R390688, Northeast Pacific
3. Pillsbury, R. D., Mesecar, R. (NSF IDOE) Marsden Square 157
4. NSF Grant No. IDO 74–12558, CUEA

Meteorology: occasional standard measurements 1
Dynamics: current meters 27

1. OSU CAYUSE Cruise C7509–F, September 1975, 1 day
2. NODC Record No. R390744, Northeast Pacific
3. Still, R. (NSF IDOE) Marsden Square 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Dynamics: current meters 1

1. OSU YAQUINA Cruise Y7505–C, May 1975, 2 days
2. NODC Record No. R390497, Northeast Pacific
3. Smith, R. L. (NSF IDOE) Marsden Square 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Physical/Chemical oceanography: STD/CTD vertical profiles 11

1. OSU YAQUINA Cruise Y7510–A, October 1975, 2 days
2. NODC Record No. R390830, Northeast Pacific
3. Huyer, A. J. (NSF IDOE) Marsden Square 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Physical/Chemical oceanography: STD/CTD vertical profiles 37

1. OSU YAQUINA Cruise Y7510–D1 and D2, October 1975, 4 days
2. NODC Record No. R390831, Northeast Pacific
3. Huyer, A. J. (NSF IDOE/ONR) Marsden Square 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Physical/Chemical oceanography: classical oceanographic stations 3, STD/CTD vertical profiles 3, expendable bathythermograph 4, expendable bathyoxygraph 12, oxygen 3, dissolved gasses 3

1. OSU YAQUINA Cruise Y7505–C, May 1975, 2 days
2. NODC Record No. R390497, Northeast Pacific
3. Smith, R. L. (NSF IDOE) Marsden Square 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Physical/Chemical oceanography: STD/CTD vertical profiles 11

1. OSU YAQUINA Cruise Y7507–C, July 1975, 2 days
2. NODC Record No. R390658, Northeast Pacific
3. Smith, R. L., Huyer, A. J. (NSF IDOE) Marsden Square 157
4. NSF Grant No. IDO 71–04211, CUEA

Meteorology: occasional standard measurements 1
Physical/Chemical oceanography: STD/CTD vertical profiles 12
Dynamics: current meters 3

Appendix B—IDOE films

The NSF Office for IDOE has prepared a number of films to better illustrate phenomena of the ocean environment and the work of IDOE-funded scientists. These 16-mm, sound and color motion pictures are available on loan from the organizations indicated.

Alpha Cine Labs
1001 Lenora Street
Seattle, WA 98121

Well of Life (27 minutes)—The twin dramas of the ocean's life cycles and the scientific probing of its mysteries are combined in this story of ocean upwelling. Coastal upwelling is the still little-understood process by which the ocean continuously renews its resources, through the motions of wind, water, and the Earth itself. The **Well of Life** deals with that mystery, and the efforts of scientists to uncover its driving forces and learn how it influences and is influenced by weather, climate, and the seemingly limitless round of ocean-linked phenomena. The setting is off the Oregon coast. But the truths presented about balance in the world's ecosystems and the relevance of one field of science to another have universal applications. (English, French, German, Spanish, and Russian versions.)

Centre Films, Inc.
1103 N. El Centro Ave.
Hollywood, CA 90038

The Turbulent Ocean (60 minutes)—A documentary film about the planning and execution of one of the largest deep-sea expeditions in twentieth century oceanographic research. Over 75 scientists and technicians from 18 national and international universities and oceanographic institutions set forth in a coordinated, cooperative effort to find and measure strange and not yet understood motions beneath the surface of the sea called an eddy.

Doubleday—Multimedia
Box 11607
1371 Reyonds Avenue
Santa Ana, CA 92705

Changing Climes (5 minutes)—Are the unusual weather patterns and severe crop losses of recent years just a passing phenomenon? Or is the Earth sliding into the downward side of a long-term temperature cycle. Scientists are detecting evidence of such long-term cycles and are raising some early warnings.

Cycle in the Sea (5 minutes)—Thanks to the motions of wind, water, and the Earth itself, life in the oceans continuously renews itself. Here is an important story of the balance in the world's ecosystems and its study off the coast of Oregon.

Desert in the Deep? (5 minutes)—That the ocean floor is no desert is beginning to be realized. But the varieties of life forms, from simple organisms to sharks measuring 4 feet between the eyes, were unsuspected until scientists went to sea with cameras able to explore the very deepest reaches of the sea.

Pastures of the Sea (5 minutes)—Food chains in the sea like food chains on land depend on plants to use the Sun's energy to convert chemical nutrients into food. To understand, and perhaps better use, the resources of the sea we have to understand its interlocking life cycles. Science is looking at the beginning of the sea's food chain; this film looks at the science.

Science and the Salmon Fishery (5 minutes)—Commercial fishermen have learned by guess and by gosh where to catch fish, but they don't often know why the fish are where they are. A scientific experiment off the Oregon coast is turning up explanations and, with the cooperation of the coho salmon fishermen, is developing a system of fisheries predictions that seems to be paying off.

Where is the Weather Born? (5 minutes)—Weather and climate, it has been said, began in the oceans. A group of scientists have been studying the northern Pacific in the effort to identify the oceanic processes relating to weather conditions over the continents. NORPAX, the North Pacific Experiment, is an effort to understand the interrelationships, for instance, between sea-surface temperatures and long-term weather (or short-term climate). This research could lead not only to understanding, but to prediction.

NOAA Film Laboratory
12227 Wilkens Avenue
Rockville, MD 20852

Boundary of Creation (27 minutes)—This film describes the efforts of U.S. and French scientists in Project FAMOUS to understand the ever-changing geology of our Earth, particularly the midocean ridges off the Azores. The picture features the probes of the minisub ALVIN in the ocean depths and also portrays research in Hawaii and Iceland.

RHR Filmedia, Inc.
48 West 48th Street
Suite #900
New York, NY 10036

Rivers of the Sea (27 minutes)—A sea-going expedition leaves Tahiti to gain a better understanding of the oceans and their chemistry—knowledge that is vital in preventing ocean pollution, improving commercial fishing, and understanding climatic conditions. It joins scientists working at sea and in land-based laboratories in California, New York, and Miami.

Appendix C—Recent Reports and Workshops Sponsored by IDOE

Effects of Pollutants on Marine Organisms. Deliberations and recommendations of the National Science Foundation, International Decade of Ocean Exploration, Effects of Pollutants on Marine Oragnisms Study, August 11–14, 1974.

Report of the Workshop on the Phenomenon Known as "El Niño." Guayaquil, Ecuador, December 4–12, 1974. Organized within the International Decade of Ocean Exploration under the sponsorship of UNESCO, FAO, and WMO.

IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources. Intergovernmental Oceanographic Commission Workshop Report No. 5. Kingston, Jamaica, February 17–22, 1975.

Report of the CCOP/SOPAC–IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific. Intergovernmental Oceanographic Commission Workshop Report No. 6. Suva, Fiji, September 1–6, 1975.

Marine Metals and Continental Ores. The Oregon Geostill Conference, October 1975, Oregon State University, Corvallis, Oreg.

A Marine Science Affairs Program in the International Decade of Ocean Exploration. Recommendations from a workshop held at the Dulles Marriott Motel, Dulles International Airport, November 5–7, 1975.

The International Decade of Ocean Exploration, midterm review. A report for the Director of the National Science Foundation by the National Advisory Committee on Oceans and Atmosphere, August 29, 1975.

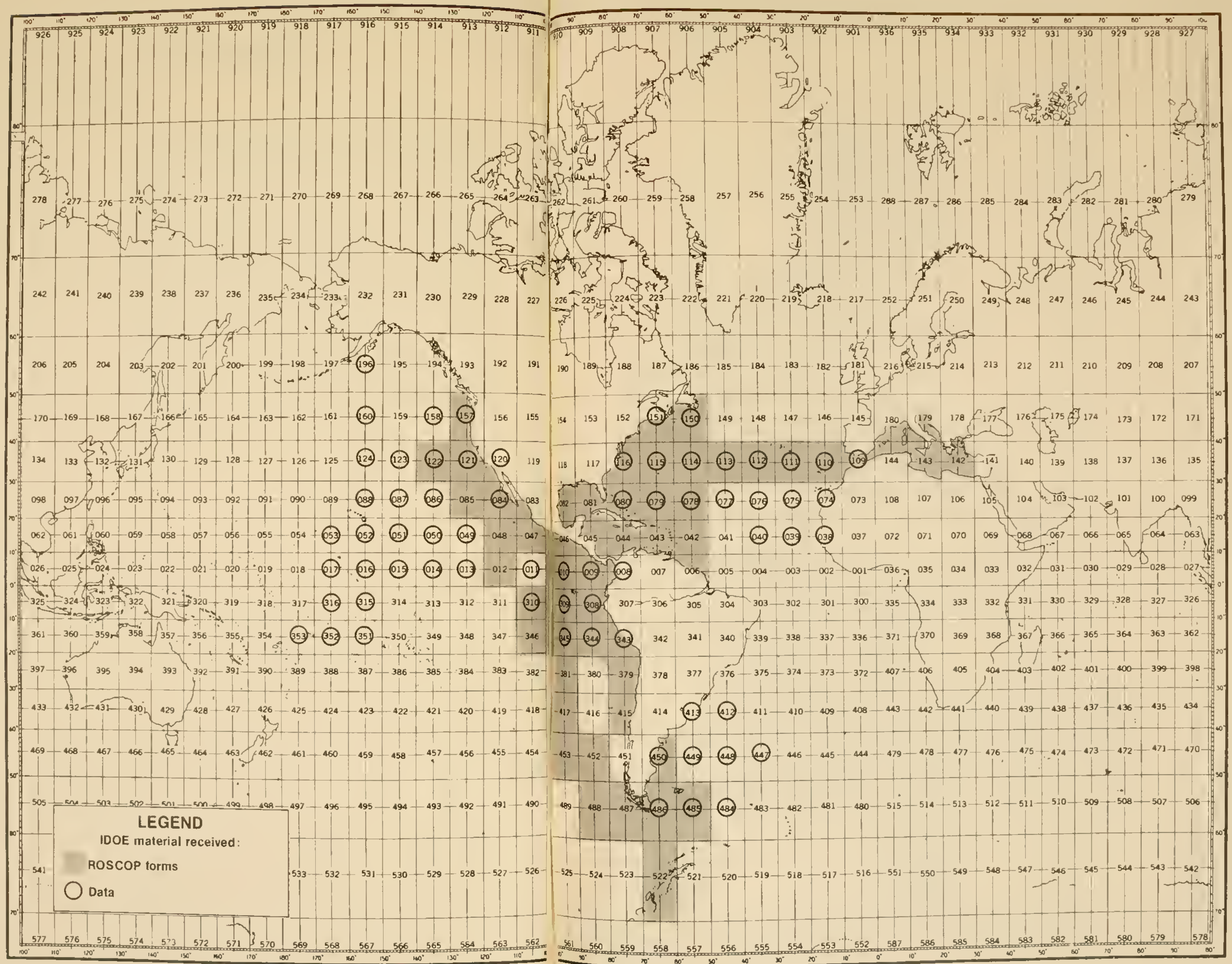

Chart of 10° by 10° geographic areas (Marsden Squares) within which were collected data and information reported in this publication and received by NOAA's Environmental Data Service. *Note:* Data and ROSCOP forms are seldom received at the same time.

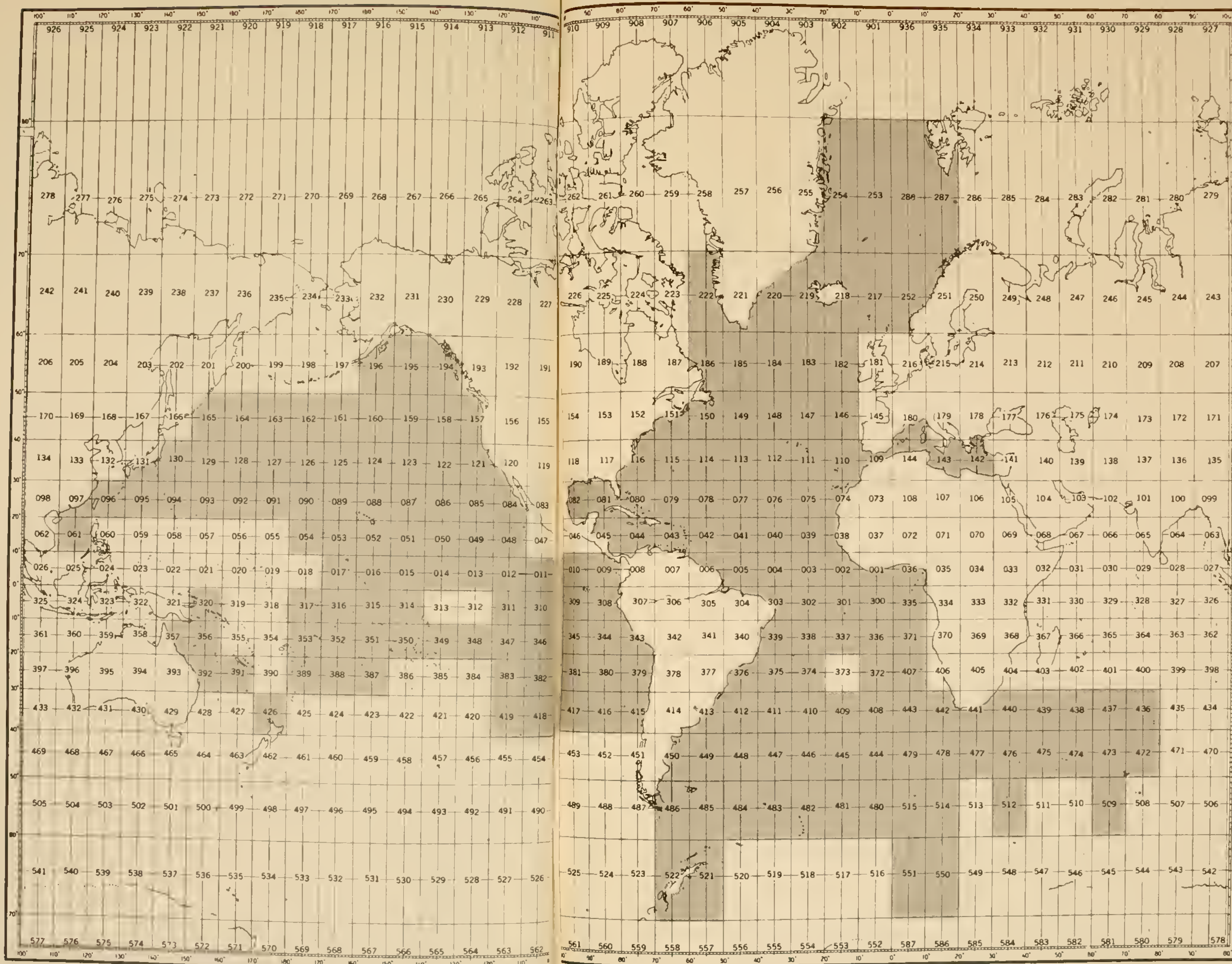

Chart of 10° by 10° geographic areas (Marsden Squares) within which were collected data received by NOAA's Environmental Data Service during the period January 1970-April 1976 (shaded squares) resulting from IDOE-sponsored research.

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